
Research Branch Directory of Research

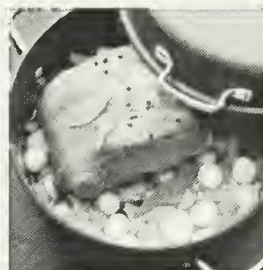
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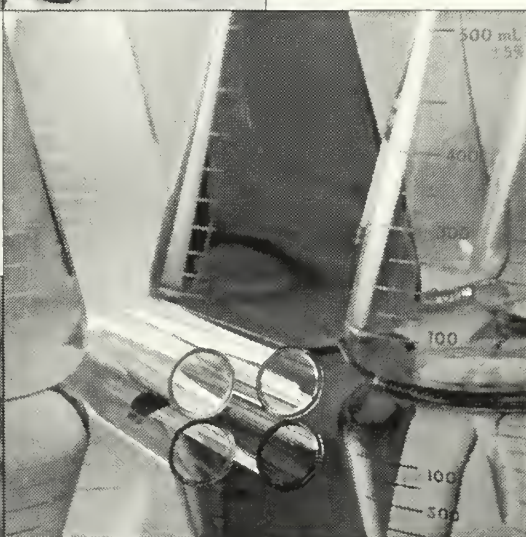
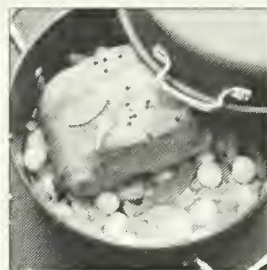
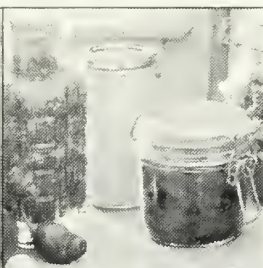


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Research Branch Directory of Research

1996 - 1997



Research Branch

Agriculture and Agri-Food Canada
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You can download a copy of each chapter from the Internet, free of charge. It is available as a WordPerfect file.

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RESEARCH BRANCH DIRECTORY OF RESEARCH 1996 - 1997

A Word from our ADM

Welcome to the *Directory of Research*. Here you should find everything you need to link directly to the Research Branch of Agriculture and Agri-Food Canada. It is our hope that producers, businesses, researchers, students, and government officials, nationally and internationally, take advantage of this directory to guide them in their search for information and contacts concerning our programs, our centres, and our people.

At Agriculture and Agri-Food Canada's Research Branch, we see ourselves in the innovation business. Innovation is a centerpiece in the federal government's new science and technology strategy - it's seen as key to Canada's economic growth and environmental well-being.

Regarding innovation, one of the important messages that we are hearing from both government and industry sources is the necessary role that partnerships have to play in ground-breaking R&D. Effective partnerships mean working directly with our clients in industry to help deliver what they need to gain competitive advantages and be successful in the marketplace.

In the Research Branch, we have attempted to integrate our clients as much as possible in our R&D investment decisions. This effort involves, first, sharing information, so that we can make informed decisions together. It entails, secondly, a co-funded partnership in R&D, through such mechanisms as our Matching Investment Initiative, to share the costs and benefits of developing innovation and transferring it to the marketplace.

The *Directory of Research* for 1996–1997 is one important way we foster innovation through partnerships, by helping our clients and potential clients get in touch with us to access information and explore collaborative opportunities. This directory helps open the door to the Research Branch. It presents each of our 18 research centres, in the following areas: staff contacts, mandate, resources, main achievements, and publications. It also includes information on Branch headquarters and, as well, the Centre for Food and Animal Research (CFAR), whose programs are in the process of being transferred to other centres during the period of this report.

Each of the Branch's research centres has a specialized focus of national importance, reflecting the strengths of our industry partners in the region of the country in which it is located. We believe that by concentrating our resources and expertise, we are better able to effectively deliver our R&D. We have achieved administrative and overhead savings, thus we can maximize resources devoted to research in each of our strategic product areas—resources, crops, animals, and food. Our centres, spanning the country and connected internationally, form specialized research networks that can address research issues along multidisciplinary and commodity lines.

This *Directory of Research* is available as a printed publication and on-line to provide you with information on our organization and activities in a format that best suits your needs. You can find the directory on ACEIS, Agriculture and Agri-Food Canada's 24-hour Electronic Information Service. For information on how to obtain printed or electronic copies of this publication, please see the instructions on the back of the title page. Again, we hope this directory proves to be a useful guide to the Research Branch for you.

Brian Morrissey, Assistant Deputy Minister, Research

RESEARCH BRANCH DIRECTORY OF RESEARCH 1996 - 1997

Headquarters

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Branch Executive

Assistant Deputy Minister, Research J.B. Morrissey, Ph.D.

Directors General

Research Planning and Coordination B. Mitchell, B.Com.

Eastern Region Y.A. Martel, Ph.D.

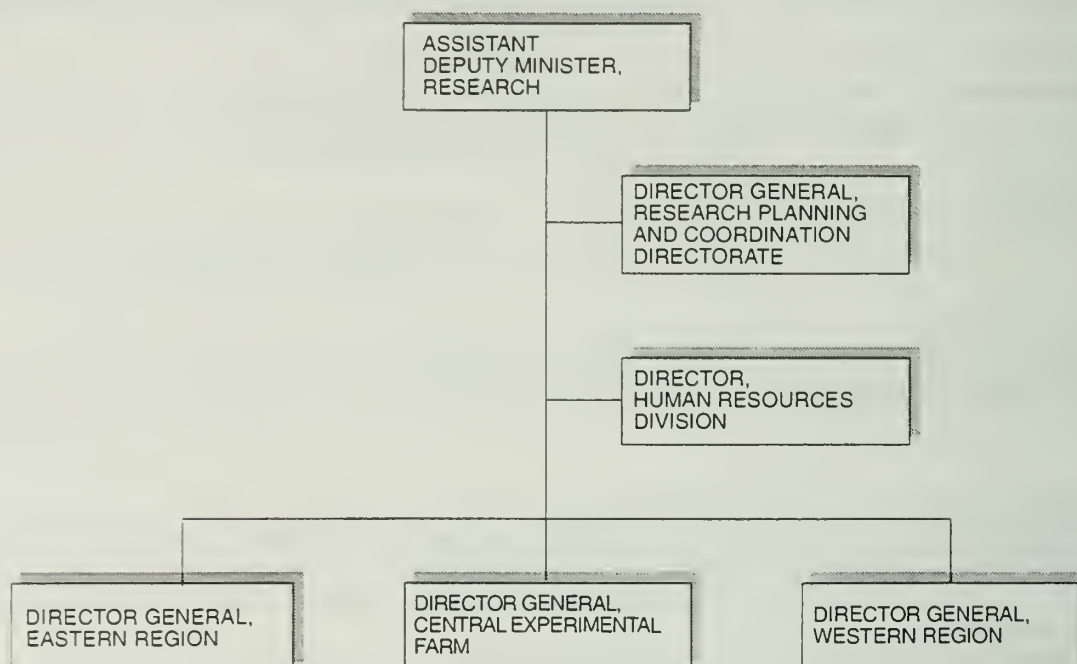
Central Experimental Farm D.G. Dorrell, Ph.D. (acting)

Western Region D.G. Dorrell, Ph.D.

Director, Human Resources Division G. Carpentier, B.A.

RESEARCH BRANCH DIRECTORY OF RESEARCH 1996 - 1997

ORGANIZATION OF THE RESEARCH BRANCH



Research Centres

Atlantic Cool Climate Crops (1)
 Charlottetown
 Atlantic Food and Horticulture (2)
 Fredericton
 Soils and Crops (3)
 Dairy and Swine (4)
 Horticulture (5)
 Food (6)
 Pest Management (7)
 Greenhouse and Processing Crops (8)
 Eastern Cereal and Oilseeds (9)

Food and Animal (10)

Cereal (11)
 Brandon
 Saskatoon
 Semiarid Prairie Agriculture (12)
 Lethbridge
 Lacombe
 Pacific Agri-Food (13)

See Map (p. 3) for location of the research establishments keyed by number

MAP OF MAJOR RESEARCH CENTRES



See *Organization of the Research Branch* (p. 2) for key to the Branch's research centres.

PROGRAMS AT MAJOR RESEARCH CENTRES

		Centres														Eastern Region			Central Experimental Farm			Western Region																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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Agriculture and
Agri-Food Canada

Agriculture et
Agroalimentaire Canada

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- *Resources*
- *Achievements*
- *Publications*

RESEARCH BRANCH DIRECTORY OF RESEARCH 1996 - 1997

Professional Staff

Director General B. Mitchell, B.Com.

Financial and Administrative Services

Director J. Taky, M.B.A.

Head, Branch Administrative Services (vacant)

Manager, Branch Financial Management S. Gascon, C.G.A.

Chief, Headquarters Administration and Resources M. Belley

Information and Planning Services

Director P. Hall, M.A.

Manager, Information Management S.L. Bolcso, M.Eng.

Manager, Promotion and Technology Transfer S.M. Rudnitski, B.Sc.

Manager, Science Policy and Planning W. Blackburn, M.Sc.

Research Coordination

Acting Director; Crop research - plants K.W. Campbell, Ph.D.

Animal research (vacant)

Crop research - biotechnology/international D. Kudirka, Ph.D.

Crop research - pest management R. Trottier, Ph.D.

Food and industrial research G.E. Timbers, Ph.D.

Food and industrial research - ethanol M. Stumborg, P.Eng.

Resource conservation - biodiversity, genetic resources B. Fraleigh, Dr.T.C. (seconded in)

Resource conservation - environment, Green Plan B. Grace, Ph.D.

Resource conservation - soil, water, climate C. De Kimpe, Dr.Sc.Agr.

Mandate

The Research Planning and Coordination Directorate (RP&C) assists the Assistant Deputy Minister and directors general to ensure a national perspective in the delivery of agri-food research and technology transfer programs. The Branch-wide services that the group provides facilitate

- research coordination and issues management, nationally and internationally
- science policy and planning
- marketing
- financial decision-making
- administration.

Resources

The Research Planning and Coordination Directorate was formed in September 1996 by combining the director general's positions for the Strategies and Planning Directorate and the Research Coordination Directorate. The new directorate brings together a total staff of 86 full-time equivalents, including 17 in the professional categories, and a total operating budget of \$6 million.

The information the directorate produces is used federally, provincially, and abroad by

- scientists, managers, and technologists doing agricultural research
- agricultural extension professionals
- politicians responsible for science policy
- educators and students studying agriculture and the environment
- farmers, producers, and processors, and other players in the agri-food industry.

Achievements

- *Interest on special purpose accounts*
- *Financial planning and analysis*
- *Visiting fellowships*
- *Fleet*
- *Matching Investment Initiative*
- *Study Management System (SMS)*
- *Research Branch Data Base (RBDB)*
- *Inventory of Canadian Agri-Food Research (ICAR)*
- *Research Branch Output Report*
- *Science and Technology (S&T) Review*
- *Intellectual property management*
- *ACEIS*
- *AGtran*
- *AGvance*
- *Success Story Library*
- *Publication inventory*
- *Promotion*
- *Marketing events*
- *Branch reviews*
- *Interdepartmental memorandum of understanding (MOU)*
- *University grants*
- *International activities*
- *National environmental research initiatives*
- *Other special-funded national programs*
- *Canadian Agri-Food Research Council (CARC)*

Interest on special purpose accounts On 7 March 1996, the directorate concluded its negotiations with the Department of Finance to have interest paid on Research Branch's specified purpose accounts. Although the government does not normally pay interest, the Department of Finance agreed that

- the amount and circumstances pertaining to the Research Branch were unique
- the interest earned could be used to fund additional research work.

The interest rate on a monthly basis equals 90% of the average of the weekly 3-month treasury bill tender rates.

Financial planning and analysis To face the continuous environmental changes affecting financial management, the directorate continues to provide to senior management financial services related to

- financial and business planning
- resource allocations
- fee structure and schedules
- cost accounting.

Visiting fellowships The Visiting Fellowships Program provides promising young scientists with the opportunity to work with research leaders in Branch laboratories across the country. In 1996 - 1997, the Research Branch signed a Memorandum of Understanding (MOU) on behalf of the Department with the National Science and Engineering Research Council (NSERC) to formalize changes to take place in the administration of the program. By virtue of this MOU, AAFC will carry out post-award administration of the fellowships starting 1 April 1997. NSERC will continue to promote the program and preselect candidates using a peer review process.

Fleet The Financial and Administrative Services Division has completed a thorough review of fleet management practices in the Research Branch. The recently approved report

- examines current procedures and systems in light of standard practices
- presents approaches and models to meet challenges such as fleet rationalization in times.

The report will be distributed before the end of the 1996-97 fiscal year.

Matching Investment Initiative The directorate provides services to support this initiative, which aims to

- strengthen market-driven priority setting in the Branch
- accelerate the process of technology transfer.

The program matches industry dollars for projects that are within the core capability of the Branch. This year the directorate developed

- new guidelines and promotional materials to assist centres establish collaborative arrangements with industry
- a management system for the initiative, including guidelines for in-kind funding.

As of February 1997, 761 projects had been approved. The federal contribution totaled approximately \$20.5 million. When coupled with industry's contribution of approximately \$22.3 million, the total value of the MII reached \$42.8 million.

Study Management System (SMS) The first steps to an integrated approach to information management across the Branch began early last year and is now entering its second phase. The SMS facilitates the selection of research studies based on

- probability of success
- payback to the nation
- cost of conducting the research.

It also collects information, tracking approximately 416 studies in progress within the Branch, from inception to the final deliverables. Enhancements have been added to the SMS with the latest version 1.4, including:

- more flexible study selection
- improved security features
- new demonstration features for users with no SMS privileges
- new publications section
- new copy (import/export) procedure for moving studies
- new report formats
- correction of past problems/bugs
- updated pick list of centre descriptions reflecting changes in centre names.

A demonstration version, available on CD-ROM, has also been created.

Research Branch Data Base (RBDB) Under development is the new *Research Branch Data Base*, which replaces the existing and aging Study Data Base. Accessing information in this database will be simplified through the use of an Internet browser. A national profile of research studies will be maintained and updated in this database and will be available to provide comprehensive information on the Branch's research activities.

Inventory of Canadian Agri-Food Research (ICAR) ICAR provides information from all sectors on more than 3200 agri-food research projects in progress. ICAR is available through the following media:

- on the Internet via Agriculture and Agri-Food Canada's Electronic Information Service (ACEIS). ICAR's URL is <http://www.agr.ca/icar/icarhome.html>.
- on the SilverPlatter's CD-ROM *Agrisearch*
- on the international on-line service *Dialog*
- on the Farm Business Management Information Network (FBNInet) of bulletin boards.

ICAR's food and human nutrition projects are available on FoodNet on the World Wide Web at <http://foodnet.fic.ca>.

A new software program to update data for ICAR is currently being developed in time for the 1997 ICAR update.

The CARC ICAR exhibit and CD-ROM demonstration were on display at the Canadian Conference on the Future of Agriculture and Agri-Food at the Winnipeg Convention Centre, 25-27 June 1996.

Research Branch Output Report This annual report lists the Branch's

- publications in its four business areas
- new cultivars
- patents
- royalties generated.

Science and Technology (S&T) Review The federal government released its strategy for S&T in March 1996. The Branch is assisting in the development of reporting requirements for federal S&T, which is integrated with the federal Expenditure Management System implementing the minister's action plan in support of the federal strategy.

Intellectual property management The directorate assists the Branch to better manage and protect its intellectual property. All the conventional mechanisms for protection and commercialization are being used by the Branch, namely

- licenses
- patents
- copyright
- Plant Breeders Rights.

It is essential that they are applied consistently across the Branch in a manner that maximizes the benefits of technology transfer to the industry while ensuring a fair financial return to the Branch for its contribution.

ACEIS Agriculture and Agri-Food Canada's Electronic Information System, ACEIS, provides a single window into all the department's information. This year the directorate updated the Branch's key corporate publications on ACEIS, including

- *Directory of Research 1996 - 1997*
- *AGvance*, a newsletter promoting technology transfer
- *AGtran*, a directory of collaborative research opportunities
- Matching Investment Initiative information.

The directorate also redesigned the Research Branch's home page to include links to what's new across the Branch, using a dynamic new template. In addition staff assumed responsibility for coordinating the Branch's presence on the Internet. Clients can access ACEIS through the Internet, fax, or telephone.

AGtran The directorate continued to update and promote this electronic catalog of technology opportunities in agri-food research.

AGvance This newsletter promotes technology transfer and collaborative arrangements to industry clients. Published quarterly, its highlights this year included

- a special issue featuring the Matching Investment Initiative
- the use of color photographs to enhance its presentation.

Success Story Library An updated version reflecting changes in the Research Branch organization and using a new Windows capability was released in 1997. It continues to be a cornerstone for the Branch's promotional activities.

Publication inventory Industry needs critical information with a comprehensive national perspective from the Branch, to maintain a competitive edge in the marketplace. To meet this need, RP&C developed a database on more than 700 of the Branch's publications. This year the inventory was transferred into the Branch's Study Management System. In this format, the centres can input data directly and obtain reports whenever they have a need. The primary aim is to help promote Branch publications to industry clients.

This year staff designed reports for accessing information on publications for use at the Branch, regional, or establishment level in preparing

- appraisals
- the *Directory of Research*
- catalogues of publications for use on the Internet and other promotional venues.

Promotion Many Research Branch successes were featured prominently in the Department's publications, displays, and media tip sheets, and in the Minister's speeches. Included were

- *Research Billboard*, highlighting successes within the Research Branch for use by the Deputy and the Minister, and featured on the Internet on the *What's New* page
- *Research Branch Information System*, the Branch's newsletter for employees, now up on the Intranet at <http://agrisource/research/rbis-sidgr/html/rbis.html>
- the display in the entrance of the Sir John Carling Building, featuring the awards received by Branch employees and the Branch's promotional activities
- *Researching our Future*, an 18-month calendar, promoting the Branch's research centres
- *Make the Connection*, a pilot brochure introducing the concept of centres of specialization and a national network of research centres for the Western Region
- ResNett, a national network of technology transfer officers, linked by e-mail into Communications Branch
- display panels promoting the Research Branch and ACEIS.

Marketing events To raise awareness of its expertise and facilities and to encourage partnerships, the Branch participated with other branches of the department during 1996 at the

- Agricultural Biotechnology International Conference in Saskatoon in June
- Canadian Excellence Conference in Winnipeg in June
- BIO Atlantech International Conference in Fredericton in October
- Life Sciences Conference in Ottawa in October
- Atlantic Technology Forum in Halifax in November.

Several of our scientists participated as speakers at these events, contributing to the

- technical and general sessions
- scientific poster presentations
- business development meetings with members of industry from both Canada and other countries
- follow-up meetings to build partnerships in response to invitations from visiting foreign officials.

Branch reviews The directorate updated the priority list for ongoing studies, and evaluated the probability of success and potential payback for new ones. Staff assisted in the review of research centres and research programs. Several coordinators participated in research scientists' promotion committees.

Interdepartmental memorandum of understanding (MOU) The directorate contributed to the implementation of an MOU on research for sustainable development involving the four natural resources departments:

- Agriculture and Agri-food
- Environment
- Fisheries and Oceans
- Natural Resources.

Coordinators are participating in the following working groups set up to foster cooperative projects:

- R&D priority setting
- climate change and variability
- metals in the environment
- coastal zone management
- ultraviolet B radiation
- informatics
- endocrines
- natural capital.

University grants The directorate conducted the annual selection process for grants to universities through the research partnership support program sponsored by the Natural Sciences and Engineering Research Council.

International activities The directorate coordinated or provided support for the following projects on behalf of the Branch:

- a memorandum of understanding with Argentina, to capitalize on the potential of international collaboration in science and technology
- the development of research priority statements with Korea
- the development of Canada's position on agricultural issues at the Conference of the Parties of the Biodiversity Convention
- the strengthening of collaboration with the Institut national de la Recherche scientifique (INRA), France
- the strengthening of cooperation with the Netherlands Agricultural Research Organization (DLO).

National environmental research initiatives As part of the departmental enviro-research initiatives, the directorate coordinated activities on topics of national relevance. Staff took the lead in reviewing experimental plans and managing the special-program funding attached to initiatives in the areas of

- climate change
- greenhouse gases
- smog
- genetic resources
- ethanol.

Other special-funded national programs The directorate addressed programs involving

- energy
- food safety
- biotechnology.

In addition, the directorate

- managed the liaison with CAB International and its affiliated biocontrol centre at Delemont, Switzerland, and strengthened international collaboration in biological control at the USDA/ARS biocontrol laboratory in Montpellier, France
- provided technical advice to other branches and the new Pest Management Regulatory Agency on issues such as IPM, biological control, and the impact of methyl bromide and other persistent pesticides on the environment
- provided support to the Great Lakes 2000 water-quality research and development program
- represented the Branch on the development of a national strategy on biotechnology
- represented the Branch on the development of a national biodiversity strategy
- represented the Branch on the development of a sustainable development strategy.

Canadian Agri-Food Research Council (CARC) Staff reviewed and acted on recommendations from regional agricultural coordinating committees and Canada committees. It provided the secretarial function and liaison to Canada committees on

- resources
- crops
- animals
- food.

Staff also

- chaired the CARC Standing Committee on Biotechnology in Agriculture and Food
- participated in the CARC Standing Committee on the Research Partnership Support Program
- acted as secretary of the Expert Committee on Integrated Pest Management.

Agriculture and Agri-Food Canada Publications

- Jack, B. 1996 (latest Internet update December). AGtran, an electronic catalogue of agri-food research technology opportunities. Research Planning and Coordination Directorate, Research Branch, Agriculture and Agri-Food Canada. Internet address: <http://www.agr.ca/research/agtran/agt-02e.html>.
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Agriculture and
Agri-Food Canada

Agriculture et
Agroalimentaire Canada

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Human Resources Division

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- *Mandate*
- *Resources*
- *Achievements*
- *Publications*

RESEARCH BRANCH DIRECTORY OF RESEARCH 1996 - 1997

Professional Staff

Director G. Carpentier, B.A.

Human Resources Advisor L. Leduc

Chief, Organizational Planning and Development B. Bertrand, M.I.R.

Manager, Human Resources and Organization Development R. Dubue, M.Ps.

Mandate

The Human Resources Division promotes and facilitates, in partnership with managers, the optimal management of human resources toward the achievement of departmental objectives. The Organizational Planning and Development Team is committed to employee well-being and organizational effectiveness.

Resources

The Human Resources Division manages a staff of 19 full-time equivalents with a budget of \$0.9 million.

Achievements

- *Agcellence Team Award*
- *Transfer of Work Program*
- *Human Resources Management Framework for the Science and Technology Community*
- *Research Branch Affiliate Program*
- *Research Scientist Promotion Exercise*
- *Management of change*
- *Demographic analysis*

Agcellence Team Award This departmental award was presented to the Human Resources Division staff in recognition of their exceptional work in helping employees and managers cope during the difficult transition period.

Transfer of Work Program This program provides Research Branch scientists the opportunity to work with distinguished colleagues to keep abreast of new scientific developments and concepts. It provides a mechanism for knowledge cultivation for our scientists, consistent with the government's focus on continuous learning.

Human Resources Management Framework for the Science and Technology Community The framework was developed

- to address the human resources issues facing the federal science and technology staff
- to align the science workforce with the government's science and technology priorities.

Research Branch Affiliate Program This program provides local managers and scientists with the opportunity to offer Canadian students an affiliate status at either the undergraduate or the graduate levels.

Research Scientist Promotion Exercise The Research Scientist Promotion Exercise is an assessment of a research scientist's achievements and productivity by management and peers.

Management of change The internal and external pressures facing Research Branch are calling for changes to practices, processes, and to the working environment. The Human Resources Division assists managers and employees coping with the changes facing the organization.

Demographic analysis The demographic analysis provides a statistical overview of the Research Branch indeterminate and term workforce, as of September 1995.

Agriculture and Agri-Food Canada Publications

Human Resources Division. 1996. Demographic analysis. Agriculture and Agri-Food Canada, Research Branch. 84 pp.

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Mandate

The Atlantic Cool Climate Crop Research Centre conducts research for crop production on mineral and peat soils under cool climate conditions. It develops techniques for

- improving forage production
- producing vegetables on peat lands
- managing stands of native fruit.

Resources

The centre has a staff of 22 full-time equivalents, including six scientists, and a total budget of \$1.6 million. Facilities located on 64 ha of land in St. John's include

- offices
- laboratories
- greenhouses
- numerous farm buildings.

Land at the St. John's site is used primarily for forage, potato, and integrated pest management trials.

Two field sites located 80 km and 67 km, respectively, from St. John's provide added field research capabilities. The peat soil of the 280-ha Colinet field site is used for

- drainage experiments
- maintenance of disease-free potato breeding stocks.

The 14-ha Avondale field site is used for

- blueberry and lingonberry trials
- field evaluation of the resistance of potato stocks to wart disease and potato cyst nematode.

The centre provides the Food Production and Inspection Branch with greenhouse space. Provincial agriculture offices are also located at the centre.

Achievements

- *Lingonberry cultivars*
- *Controlled-release fertilizer*
- *Fertilizer placement*
- *Plant diseases*
- *Agricultural machinery*
- *Integrated pest management*
- *Red-clover-root-feeding insects*
- *No-till seeding*
- *New forage crop evaluation*
- *Feed grains*
- *Land resources*
- *Clubroot-resistant rutabaga*
- *Wart-resistant potato*

Lingonberry cultivars Trials to determine the suitability of the European lingonberry for commercial production in Newfoundland were established at St. John's and Pynn's Brook through a joint federal - provincial project in 1992. Plant establishment was a problem in areas where snowfall was inadequate to provide protection from heaving. In 1996, the cultivars Koralle, Ammerland, and Red Pearl produced a large crop of red berries at the Pynn's Brook site, whereas only Koralle produced fruit at St. John's. The other cultivars had mostly immature berries at the end of the growing season. This finding indicates that fruit maturity could be a problem with some cultivars.

Controlled-release fertilizer The availability of nutrients in Plantacote Depot 4M (14-9-15) and 6M (14-9-15), two products from Germany with different nutrient-release times, was assessed on celery grown on peat soil. Yields were low due to extensive crop injury caused by a severe frost shortly after planting. Marketable yield increased from 0.0 to 47.0 t/ha with an increase in the nitrogen rate from 150 to 450 kg/ha. Yield was significantly higher with "Depot 4 M" than with "Depot 6 M". Adding 15% "Plantacote Start" fertilizer to the fertilizer treatment increased yield, but further additions were of no benefit.

Fertilizer placement Banded and broadcast applications of conventional fertilizer were evaluated on celery grown on peat soil. Greatest production was obtained with N and K at rates of 250 and 457 kg/ha, respectively. Yields were 48% higher with a broadcast application than with a band application.

Plant diseases Fatty acid analysis of *Synchytrium endobioticum*, the causal agent of wart disease of potato, indicates pathotypes are chemically separable; DNA analysis is under way to confirm this finding. Both projects are supported by contracts under the Matching Investment Initiative (MII). Spores of *S. endobioticum*, although soil-borne, can be wind-borne in dry windy weather. Vehicle infestation by *S. endobioticum* was positively correlated with infested gardens. In a 3-year study, *S. endobioticum* found in or on vehicles at ferry inspection stations proved to be infective; about 8% of the vehicles had viable spores.

Brassicas infected with the clubroot pathogen showed increased resistance with increasing amounts of field-applied crushed crab shell.

Agricultural machinery A 3-year MII contract aimed at the development of a practical forage-harvesting system for peat soils began this year. The objectives of the on-farm project are to identify

- suitable sites and drainage conditions
- practical methods and equipment for seeding and harvesting forage crops.

In 1996, several seeding methods were examined. A conventional double-disk seeder was found to be most effective. In the next 2 years, harvesting equipment will be evaluated, including a front-mounted mower for increased maneuverability on narrow fields.

Integrated pest management A 3-year project on forecasting cabbage root maggot was completed. Dr. Rosemary Collier of Horticulture Research International (HRI) visited the centre to assess the suitability of data from 20 commercial fields, in an HRI forecasting model.

A Masters of Science project showed that

- carrot rust fly cultivar resistance is due partially to oviposition preference
- the pest is widespread in Newfoundland.

Two pheromones, field-tested for monitoring, trapped large numbers of the lingonberry fruitworm.

Red-clover-root-feeding insects In a study of the behavior of insects feeding on red clover roots, *Sitona flavescens* was identified for the first time in Newfoundland soils. Insect-feeding damage to red clover roots is suspected to be an important mechanism for the introduction of root pathogens that reduce crop persistence.

No-till seeding A heavy-duty double-disk press drill with independently mounted openers gave excellent establishment of both timothy - clover and winter wheat on stony forage land. Machines without independently mounted openers have problems with the very uneven land common to the Cochrane soil series in eastern Newfoundland. This new seeder appeared to overcome these problems.

New forage crop evaluation Goat's rue (*Galega orientalis*) in the 2nd year of production again survived the winter well with vigorous early spring growth, but second-cut production was not as good as it was with alfalfa at a well-drained site. Goat's rue is performing well compared with red clover in this eastern Newfoundland trial. An evaluation of the crop on wetter land commonly seeded to timothy - red clover mixtures would be useful.

Feed grains The 1st year of a seeding date trial has been completed using Chapais barley. Grain and straw yields decreased linearly with later seeding dates between 9 May and 4 June. Seeding dates after 4 June resulted in projected grain and straw revenues being much below the cost of production.

Borden winter wheat yielded 6.6 tonnes of grain and 9.2 tonnes of straw per hectare in trials conducted at St. John's. These yields suggest a potential high return for producers in eastern Newfoundland. Further research is needed to establish the level of risk for winterkill in eastern Newfoundland.

Land resources A Canada - Newfoundland Agreement on Green Plan sponsored a project to carry out an enhanced on-farm mapping program for the centre. Analysis of soil samples and elevations collected in detail from each field will be used for precision-enhanced farm management. A precision farming model prototype is being developed between Geographic Data Services and the centre as part of a Matching Investment Initiative. This prototype will examine the relationships of yields to measured soil and topography variables.

Newfoundland's portion of the National Soil Data Base has been completed. Data are available in hard copy or digital format through the Canadian Soil Information System (CanSIS).

Clubroot-resistant rutabaga A.C. Brookfield is a green-topped rutabaga cultivar with

- resistance to clubroot disease
- low susceptibility to damage by the cabbage root maggot.

Trials were conducted overseas by Parson Seeds of Beeton, Ontario, through the Matching Investment Initiatives program. As a result A.C. Brookfield has been accepted on the U.K. National List and granted Plant Breeders Rights.

Earlier-maturing roots selected from crosses made with the U.K. cultivar Lizzy appear to be more susceptible to storage rots than is the standard cultivar Laurentian. Further evaluation of these lines has been discontinued.

Wart-resistant potato The red-skinned selection N1695-22, obtained from a cross of Brigus and Redsen, continues to perform well in trials and with commercial growers. This cultivar was named Red Island through a public competition. In addition to wart resistance, it had good resistance to tuber blight and was free from scab infections in 1996. Application will be made for registration.

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Mandate

The Charlottetown Research Centre has a mandate for conducting research on potato management and feed crops and serves as the centre for sustainable potato production systems. It conducts research on

- cereal and forage crops
- management, protection, and nutrition of potatoes
- soil management and conservation
- swine nutrition.

Resources

The research centre operates with a total budget of \$5.9 million, including about \$0.5 million in MII and other funding programs. It houses under one roof approximately 73 full-time staff, including 16 scientific staff. Also accommodated at the centre is the staff of the

- Agriculture Division of the Prince Edward Island Department of Agriculture, Fisheries and Forestry
- Atlantic regional and Prince Edward Island district offices of the department's Market and Industry Services Branch
- Prince Edward Island district office of the Agricultural Inspection Directorate of the department's Food Production and Inspection Branch.

The research centre operates two other properties:

- Upton Farm, where the forage research program is located
- Harrington Farm, which accommodates about 70% of the centre's field studies in cereals, forages, potatoes, and soil tillage and conservation.

The three locations have a total land base of 383 ha.

Achievements

- *Staff awards and honors*
- *Research direction*
- *New cereal and forage cultivars*
- *Integrated disease control in barley*
- *Rejuvenating pastures*
- *Rhizobium*
- *Late blight*
- *Verticillium wilt*
- *Insect management*
- *Integrated pest management in cole crops*
- *Quackgrass control*
- *Potato waste compost*
- *Potato-variety development*
- *Potato planter*
- *Wild blueberry*
- *Rill erosion in potato rotations*
- *Conservation tillage*
- *Soil quality*
- *Ecological framework for Canada*
- *Soil formation*
- *Environmental Farm Plan*
- *Soil capability rating*
- *Liquid hog manure storage*

Staff awards and honors In July 1996, B.R. Christie was made an Honorary Life Member of the Canadian Seed Growers Association.

Research direction Stakeholders at a meeting in January 1996 reviewed the research direction of the centre. They agreed the potato program will focus on sustainable potato crop production and the management of pests and soils. The feed crops program will be directed toward the development of new cultivars and management of crops and pests. Research between programs will be integrated using multidisciplinary teams to ensure

- integrated production practices
- viable sustainable rotations
- long-term maintenance of the soil resource.

New cereal and forage cultivars AC Wilmot is a high-yielding spring feed wheat, yielding 10% more than control cultivars. It has a similar disease response to the better check cultivars for

- powdery mildew
- septoria leaf and glume blotch
- fusarium head blight.

AC Endure is a new cultivar of red clover released in 1996. It is more winter hardy than the cultivars currently available and will make red clover more valuable for hay or silage production.

Climax is a commonly grown high-yielding timothy, but several new cultivars offer advantages over it. These new timothies

- recover faster after harvest

- are higher in crude protein and minerals
- provide greater leaf content
- provide lower dry matter content.

Integrated disease control in barley The two basic chemical control methods for net blotch in barley are

- seed treatment
- foliar spray.

Studies showed that cultivar selection is critical in effective disease-control strategies. Although seed and foliar treatments have a positive effect on disease control and yield enhancement, the use of resistant cultivars was of key importance. Propiconazole as a foliar spray and the seed treatment triadimenol were similarly effective in increasing yield responses.

Rejuvenating pastures A mixture of white clover and perennial ryegrass increased total yields and clover content of naturalized pastures when it was direct drilled or seeded in cultivated seed beds. Loosening the soil by para-plowing tended to reduce the yields of naturalized swards. Nitrogen concentration and digestibility of dry matter were greatest in sown pastures.

Rhizobium A cooperative research project was carried out with the Prince Edward Island Department of Agriculture, Fisheries and Forestry and the Nova Scotia Agricultural College. Results demonstrated that the *Rhizobium* bacteria, normally found in nodules on the roots of legume species, can infect other plant species. The ability of *Rhizobium* to fix nitrogen in the nodules of red clover is affected by other species of bacteria which may be present. The interactions among bacteria in the soil and roots of plants may have dramatic effects on crop performance.

Late blight Scientists have demonstrated a continued change in the pathotypes present in the pathogen populations of late blight in potato across Canada. Some of the new types appear more aggressive, and potato producers had difficulty controlling the disease. When the disease pressures were very high, all the commercially available fungicides and most chemicals in developmental stages prior to registration were ineffective in halting established disease. Disease prevention methods provided much more effective disease management. In studies on oospore development, these sexually produced spores were found to survive many months outside of living host tissues.

Verticillium wilt Field studies have revealed more about the nature of a unique pathotype of *Verticillium albo-atrum*. Unlike the traditional pathotype found in most cool, moist climates, this new one is less pathogenic but able to compete with the traditional pathotype. Further investigations, utilizing genetic analyses methods based on the polymerase chain reaction (PCR) developed for this and associated *Verticillium* species, are being conducted to determine the potential for biocontrol. Detection of three *Verticillium* species in soils has been dramatically enhanced with the use of a 'nested' PCR technique.

Insect management Scientists assessed methods for determining the presence of the European corn borer and the potential impact of infestation levels on yield of potatoes. Trapping adult males and surveying potato plants for egg masses of the pest from 250–500 degree-days (about mid to late July) was found to be the most reliable method.

Integrated pest management in cole crops The application of an insecticide when 40% of the plants have at least one insect pest present is a rapid and reliable method of managing leaf-feeding pests of cabbage.

Quackgrass control Clethodim gave excellent control of quackgrass in potatoes, with no injury to the crop. Level of control was not improved by addition of ammonium sulfate. Addition of the surfactant CC-16255, however, allowed rates of clethodim to be reduced by more than 50% while still giving excellent control.

A comparison of glyphosate with sulfosate for control of quackgrass regrowth in the fall in cereal stubble showed that both gave comparable levels of control at equivalent rates of application. Addition of tallow amine ethoxylate to

the spray mixture with either herbicide gave increased control at lower rates, but no response at higher rates of application.

Potato waste compost Potato waste composted with sawdust and manure increased potato yields whenever it was applied in a potato - barley - clover rotation. The compost had various affects on the amount of fertilizer N required to obtain maximum potato yields.

Potato-variety development The optimum nitrogen rate for AC Novachip, recently released by the department, was less than that for a Frito-Lay cultivar, NorWis, and a commercial potato chip cultivar, Norchip. Yield at in-row seed-piece spacings of 20 or 25 cm was greater than at 30 cm for all cultivars.

Potato planter A small two-row potato planter with a cone-type fertilizer applicator was built. Variable-speed gear boxes used to control the speed of the planting belt allow for a quick method of changing

- in-row seed-piece spacing per individual row
- the rate of fertilizer applications.

Wild blueberry Repeated application of phosphorus fertilization in wild blueberry resulted in a build-up of soil phosphorus. Over 4 years, phosphorus had little effect on

- plant growth (total stem length)
- yield potential (buds and blossoms)
- fresh fruit yields.

Commercial producers should apply phosphorus-containing fertilizer with considerable caution. They should leave control areas in the field for comparison.

An atlas of production areas, indicating exactly where blueberries grow and on what soils they are found, overlaid on soils maps is being produced for Cumberland, Colchester, and Pictou Counties, the major blueberry-growing area of Nova Scotia.

An air photo and image analysis technique to map percentage cover in blueberry fields was developed.

Classification was based on

- percentage of bare ground
- blueberry plants
- weeds.

The technique has applications in differential rates of herbicide application.

Rill erosion in potato rotations A field transect method of rill cross-section measurement was used to determine cool-period soil loss on more than 30 site years, for a typical 3-year rotation of grain - hay - potato. The results were compared with those for a typical 2-year rotation of grain - potato. Cool-period soil loss under 2-year rotations is 5 t/ha greater than it is under 3-year rotations. The results confirms the age-old merits of advocating longer rather than shorter potato rotations.

A soil-saving crop planner was developed as an interactive package for use on the farm. It links the revised universal soil loss equation with ArcView to aid in choosing crop rotations that meet erosion-reduction targets.

Conservation tillage The adoption of conservation tillage in Prince Edward Island involves a combination of techniques and approaches, because of

- the predominance of mixed-farming systems
- the constraints of soil and climate.

In long-term studies, several types of conservation tillage can be successfully used without any loss in yield potential or crop productivity, compared with conventional tillage. Successful conservation tillage strategies include

- minimum tillage
- direct drilling
- rotational tillage
- shifting time of tillage from the fall to the spring.

Residue management is a conservation tillage practice that promotes the conserving of crop residue from the previous crop on or near the soil surface. This method has been found to be practicable and effective in potato fields in Prince Edward Island. Compared with traditional tillage methods, residue management in potato rotations in the potato year

- reduces soil erosion rates by as much as 90%
- saves farmers between \$75 and \$85 a hectare.

Soil quality Microbial biomass was estimated by ninhydrin-reactive nitrogen, using liquid chloroform. The method provides a fast and useful estimate of soil microbial biomass and microbial activity in agricultural soils.

A study has been conducted over 7 years at a Nova Scotia benchmark site under a corn - forage rotation on a Gleyed Gray Luvisolic soil (Queens series). Soil organic carbon declined 10% and the carbon-to-nitrogen (C:N) ratio and total nitrogen decreased 5%. Spatial distribution of high carbon levels and C:N ratios at the site was linked to land clearing activities.

Ecological framework for Canada The Ecological Framework for Canada is a strategic tool useful for

- planning environmental assessments
- research
- monitoring networks
- reporting and communicating ecological concepts.

Fourteen ecoregions and 54 ecodistricts were established for the Maritime Provinces.

Soil formation The catena of Podzolic Gray Luvisols (Falmouth series) - Gleyed Brunisolic Gray Luvisols (Queens series) - Orthic Luvic Gleysols (Kingsville series) is common in agricultural landscapes of Nova Scotia. Micromorphological investigations of soil profile development of Podzolic Gray Luvisols (Falmouth series) indicated that the podzolic B horizon developed in degraded Bt horizons.

In cooperation with the Nova Scotia Department of Agriculture, guidelines were set for topsoil manufacture as an alternative to stripping agricultural or forest land for topsoil.

Environmental Farm Plan A working group set up the guidelines to implement the Environmental Farm Plan in the Atlantic Provinces. A dBase program was written to calculate

- hydrologic soil group
- wind erosion hazard
- water erosion hazard
- compaction hazard for every agricultural soil.

Soil capability rating Soils with a high capability for potato production were identified in Cumberland County, Nova Scotia, and separated on the basis of those that are currently in agriculture from those currently under forest.

In cooperation with the Nova Scotia Agricultural College, potential areas were identified in Nova Scotia that are suitable for growing hemp for fiber.

A package of soil capability and agricultural land use maps was assembled at the request of the Federation of Agriculture and Municipal Planners to help in assigning land to the agricultural zone of Kings County, Nova Scotia.

Liquid hog manure storage Facilities on Prince Edward Island were sampled for nutrient content. Analysis of samples on a dry matter basis revealed up to twofold differences in nutrient content between farms. On a volume basis, the differences were as great as four times. Dry matter content of the manure could be used to predict P, Ca, Mg, S, Mn, and Fe but not $\text{NH}_4\text{-N}$, Zn, K, B, or Cu.

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Mandate

The Atlantic Food and Horticulture Research Centre develops new cultivars and technologies for the production, adaptation, and protection of horticultural crops. In addition, it develops innovative technology for their storage, handling and processing. The centre also studies the nutrition and management of poultry.

Resources

The centre has 77 full-time equivalents including 24 scientists. It manages a budget of \$6.5 million, including about \$1 million in MII and other special funding programs. The centre encompasses 188 ha on the eastern limits of Kentville and an additional 74 ha at its Sheffield Research Farm, 8 km north of the centre. The laboratory-office complex integrates the Research and the Food Production and Inspection branches of Agriculture and Agri-Food Canada, as well as the western regional staff of the Nova Scotia Department of Agriculture and Marketing. The centre also includes the Senator Hervé J. Michaud Research Farm, which encompasses an additional 28 ha of land near Bouctouche, New Brunswick.

Achievements

- *Staff awards and honors*
- *Native bees in lowbush blueberries*
- *Soil pH and lowbush blueberries*
- *Improved timing of fungicide sprays*
- *New pesticides for lowbush blueberries*
- *Blueberry storage*
- *Frozen lowbush blueberry quality*
- *Strawberry plant dormancy*
- *Pest control in strawberries*
- *Shipping and storage of fresh strawberries*
- *Expanding raspberry production*
- *Accelerated cultivar development*
- *Standardizing sensory assessments*
- *Toward a better apple pie*
- *Biological control of mites in orchards*
- *Deterioration in storage*
- *Management of processing tomatoes*
- *Organic amendments in vegetable production*
- *Reducing waste of perishable produce*
- *Consolidating poultry research*
- *New statistical software for cultivar trials*

Staff awards and honors Dr. P.R. Hicklenton was elected President of the Canadian Society for Horticultural Science.

Native bees in lowbush blueberries Native bees, especially bumble bees and *Adrena* spp., comprised a significant portion of the forager force on lowbush blueberries. Pollen-foraging alfalfa leafcutter bees, native and managed bees, successfully pollinated more flowers and deposited more pollen than did nectar-foraging leafcutter and honey bees. Conservation of native bee populations could

- lead to improved pollination
- reduce the dependence on the use of honey bees.

Soil pH and lowbush blueberries Lowbush blueberries are assumed to be acid-loving plants requiring low soil pH, but research and commercial trials shows no difference in productivity of select clones grown in soils ranging in pH 4–6. Therefore, select clone blueberries can be incorporated into mixed-fruit farming without the need to acidify the soils.

Improved timing of fungicide sprays Timing of fungicide sprays to control *Botrytis* blight on lowbush blueberry can be greatly improved by monitoring spore production of *Botrytis cinerea* on sheep sorrel in the fields. This weed is a significant source of the initial inoculum that infects the blueberry blossom. It provides producers with an easily observable means of forecasting blight potential.

New pesticides for lowbush blueberries Three new pesticides have become available in this regionally important crop under the User Requested Minor Use Label Extension program:

- hexazinone for weed control in the harvest year
- fluazifop-p for grass control in the prune year
- propiconazole for *Monolinia* blight control.

Blueberry storage Vinyl tents have been developed as a practical and inexpensive way to hold several pallets of packaged fruit in controlled-atmosphere environments. These tents were successfully tested for use with packaged highbush blueberry fruit.

Frozen lowbush blueberry quality A major collaborative study involving several Canadian and US partners was done on the postharvest handling and processing practices at commercial plants. The freezing process and frozen storage conditions greatly influenced the quality of the frozen product – more so even than pre-processing practices. This information will allow processors to significantly improve the quality of their product.

Strawberry plant dormancy Concentrations of soluble sugars and starch in the roots and shoots are closely related to the onset of dormancy in strawberry plants. The pattern of carbohydrate accumulation in the fall may be a useful means to determine when strawberry nursery plants are sufficiently dormant for digging and storage.

Pest control in strawberries Intensive monitoring of two-spotted spider mites, an important pest of strawberries, resulted in a new strategy of early detection and control for planting-year strawberries. Producers have been quick to adopt this new strategy.

An inoculation technique that provides consistent and natural infection of strawberry leaves by *Xanthomonas fragaria* was developed. This breakthrough is now making it possible to conduct a wide range of resistance studies. These are funded in part by the North American Strawberry Growers' Association.

Shipping and storage of fresh strawberries Fresh, locally grown strawberries can be successfully exported if they are picked frequently at the proper maturity and rapidly cooled before shipping. Cultivars from the Kentville breeding program have now been evaluated for their shipping potential. Cooled, fresh strawberries should be held in 15% CO₂. This treatment

- enhances firmness and color
- reduces decay.

Expanding raspberry production Hardiness and poor yields are constraints to raspberry production in the Maritimes. Windbreaks were shown to enhance

- survival
- growth
- yield.

Winter survival is less important with primocane-fruiting cultivars, and four were identified as well suited to the region. Furthermore, summer pruning increased fruit yield and quality when compared with conventional after-harvest pruning.

Accelerated cultivar development A growers' association for testing of apple cultivars has been established. Collaborating producers will grow and manage promising selections from the breeding program. This approach will

- provide sufficient material for advanced testing
- familiarize the industry with new material.

Industry will also support and assist in directing a research associate to adapt and use genetic transformation.

Standardizing sensory assessments A standardized methodology for the sensory description of apples was developed. Included are reference materials to illustrate defined terms clearly. The material is being used by trained panellists to evaluate selections in the tree fruit breeding program, but it has potential wherever quality must be quantified.

Toward a better apple pie Expansion of the baked-products market for apples is limited by availability of suitable cultivars. Working closely with industry, researchers on sensory quality of processed apples have implemented commercial-scale processing trials using a Kentville-bred scab-resistant cultivar.

Biological control of mites in orchards Three years ago, insecticide-resistant predaceous *Typhlodromus pyri* was released in commercial orchards. The insect has established itself in most orchards to levels that permit cooperators to redistribute the predator. Effective control of phytophagous mites was obtained in half the orchards. Failures occurred when the cooperator selected inappropriate pesticides.

Deterioration in storage Induced ethanol production is common in many fruits and vegetables kept in poor or injurious storage environments. Ethanol is easy to detect and its presence reflects loss of quality and shelf-life before other signs are visible. Ethanol detection could be a useful tool in monitoring quality during storage.

Management of processing tomatoes To maintain local markets for processed tomatoes, it is important to improve yields and quality. Producing transplants in larger than standard plugs

- reduced transplant shock
- reduced time to harvest by 4–6 days
- increased yields by 12 to 29%.

Higher yields could also be obtained with some cultivars by modifying planting densities.

Organic amendments in vegetable production Several soil amendments based on marine by-products were compared at equivalent levels of N with commercial fertilizers. Overall, the residual value of the amendments were similar to inorganic fertilizers in a long-term vegetable crop rotation. Their use elevated soil pH.

Reducing waste of perishable produce A study on handling and storage of produce at the retail level has culminated in a poster titled *Produce Handler's Guide*. A smaller version was prepared for consumers. Interest in reducing waste by improving their practices is increasing among retailers and consumers.

Consolidating poultry research The feed milling and hatchery facilities at the centre will be relocated to the Nova Scotia Agricultural College in Truro. This move is jointly funded by federal and provincial departments of agriculture. The transfer and installation of this equipment is part of a memorandum of understanding that will consolidate the poultry programs at Kentville and the Nova Scotia Agricultural College.

New statistical software for cultivar trials An easy-to-use suite of statistical programs has been developed to manage multi-site cultivar trials of annual crops. It efficiently

- designs, randomizes, and organizes field trials for sets of cultivars at several sites
- analyzes the results
- prepares annual and cumulative reports.

Better statistical models can evolve as sources of variation becomes known. Improved models provide better information to breeders and testing agencies and can be used to optimize resources.

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Mandate

The Fredericton Research Centre develops new cultivars and technologies for the production, handling, and management of potatoes. The centre also maintains a national repository of potato gene resources and conducts research on soil management and conservation. In addition, the centre develops technologies for sustainable food production from beef cattle integrating land, forage, and animal resources at the Nappan Research Farm.

Resources

The centre has a total staff of 102 full-time equivalents including 24 professionals. It manages a budget of \$7.3 million, including \$1.7 million in MII and other special funding. The land base at three locations covers 885 ha. The centre operates a potato-breeding field site at Benton Ridge, about 100 km west of Fredericton, and a research farm at Nappan, N.S. The Nappan Research Farm shares its facilities with the regional extension offices of the Nova Scotia Department of Agriculture and Marketing and the Maritime Beef and Swine Test centers. The centre also shares its office - laboratory building with the Food Production and Inspection and Market and Industry Services branches of Agriculture and Agri-Food Canada and with head offices of the New Brunswick Department of Agriculture and Rural Development.

Achievements

- *Propagation*
- *Cultivar releases*
- *Germplasm improvement*
- *Sustainable insect management*
- *Potato virus genome*
- *Remote sensing*
- *Pesticide leaching*
- *Soils*
- *Mechanical injury*
- *Beef*
- *Dairy*
- *Forages*

Propagation Trials were done on fertilizer and spacing requirements of potato plantlets grown in the greenhouse to produce minitubers. Results:

- Over-fertilization of stock plants can result in lower yields.
- Spacing changes can optimize the performance of individual cultivars.
- Stem elongation of some cultivars can be promoted by the use of a yellow filter.
- Regeneration and growth of plantlets from various cultured plant tissues of several potato cultivars has been successful.

Cultivar releases Exclusive seed distribution rights have been awarded to the Ontario Seed Potato Growers Association for three new fresh market cultivars:

- OAC Royal Gold
- OAC Ruby Gold
- OAC Temagami.

Several advanced french fry selections are being tested by commercial processors.

Germplasm improvement In field trials transgenic lines synthesized with the PLRV coat protein gene in cultivars Snowden and Yukon Gold showed PLRV resistance ranging from 10% to 100%. In a comparison of screening strategies for scab resistance, individual and family selection methods were equally efficient for identifying superior progenies, whereas within-family selection was less effective. Tetraploid progenies from 4X - 2X matings and from 4X - 4X matings were significantly different for some quantitative traits. Genes for several traits were close to the centromere and genes for yield were distributed throughout the chromosomes. Several physiological mutants have been identified and distributed to collaborating researchers for further molecular and physiological studies. Mutants include

- chipping ability of potatoes stored at cold temperature
- abscisic acid deficiency
- a nuclear-controlled chlorophyll type.

Sustainable insect management The prospects for developing a sustainable management program for the insect pests of the potato crop have been detailed in a book based on a national symposium. This work has played a seminal role in building up interest in a national integrated pest management strategy for the Colorado potato beetle. A review of existing programs was done during a workshop of the Entomological Society of Canada and the Pest Management Regulatory Agency's working group.

Potato virus genome The complete nucleotide sequence of the PVY^o strain was determined. It consists of 9698 nucleotides and is shorter than other strains. The complete genome was cloned in eight segments and used for virus detection as a cDNA probe. Using sequence data, primers formed through the polymerase chain reaction (PCR) were

synthesized for detection of PVY^o in dormant tubers and aphids. A duplex PCR was developed to detect PLRV and PVY from the same sample. PCR methods can detect nucleic acids at levels as low as 1 pg.

Remote sensing Radar's potential to describe crop status could lead to improved potato management. Radar scattering with decreasing leaf water levels is due to leaf thinning and wilting and not to changes in the leaf's permittivity. Differences with an existing remote sensing model may be due to an inadequate physical model of the potato leaf.

Pesticide leaching A field study was done on the leaching potential of metalaxyl, a fungicide applied to the potato crop. The normal use pattern of metalaxyl in Atlantic Canada is unlikely to cause ground-water contamination in excess of 5 mg/L. This level is well below the proposed Canadian drinking water guideline of 500 mg/L.

Following an accidental point source release of approximately 60 g of atrazine in a corn field, 18 g were recovered in tile drainage effluent after a single 70-mm rain storm. Simulation results indicated that no atrazine would be transported to drain depth under these conditions.

Soils Municipal solid waste compost or manure was compared, with and without added N fertilizer. Results:

- Barley boot stage tissue concentrations of N, K, and Mn were higher with the manure than the compost.
- Na, Mg, and Cu concentrations were higher in the compost-amended plots.
- Ca, Fe, Zn, and B were not affected by amendment type.
- Manure produced higher grain yields than compost.

Mechanical injury Severe injury to potatoes during harvesting increased with

- lower tuber temperature
- longer time lapses between vine killing and potato harvesting.

In a 3-year study, the relative susceptibility of potato cultivars to serious mechanical injury remained consistent. A computer-based multimedia product was designed

- to increase the awareness of the mechanical injury of potatoes
- to outline the preventative steps that might be taken to reduce the problem.

Beef Research with finishing cattle has shown that fat supplementation of pasture and silage increased gain and degree of finish. Inexpensive fat sources in the region could be used to improve finish in forage-fed cattle. Researchers are investigating the potential to manipulate fatty acid profiles to make beef fat more desirable from a human health standpoint.

Dairy Dairy cows in late lactation derive more energy from diets having more rapidly digested fiber, but use the additional energy for gain in body weight, not for milk production.

Forages AC Langille was released to private industry. It is a new birds'-foot trefoil cultivar with superior

- seedling vigor
- persistence
- herbage yield.

Early-maturing timothy cultivars had a greater nutritive value in terms of digestibility and concentration of neutral detergent fiber than late-maturing cultivars, when compared at a same growth stage. Early-maturing timothy cultivars also have a greater rate of leaf extension and final leaf length than late-maturing cultivars.

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Mandate

The Research and Development Centre at Sainte-Foy develops new cultivars of forage crops, primarily alfalfa and timothy for eastern Canada. It also conducts research on

- soil and water conservation for Quebec
- forage and grain production
- wheat improvement.

In addition, the centre develops techniques for producing and using forages in central northern areas.

Resources

The centre is close to Laval University, which houses one of the most important faculties of agriculture in the country. It has a staff of 72 full-time equivalents, including 23 scientists. Its total budget is approximately \$7 million, including funding for the Matching Investment Initiative and other special projects. The centre operates a 75-ha field site at Saint-David-de-l'Auberivière, about 15 km south of Quebec, where work on plant production is done. The centre is also in charge of the 140-ha Normandin Research Farm northwest of Lac Saint-Jean.

Achievements

- *Glenn Downing Prize from the CSAE*
- *Nitrous oxide emissions from soils*
- *Direct seeding and soil carbon*
- *Grain corn yield and pedological properties of soils*
- *Soil structure and young organic matter*
- *Quebec soil names database*
- *Pedological reference framework for correlating soils*
- *Use of composts in cereal production*
- *Oxidation of soil organic matter*
- *Phosphorus in soil water drainage*
- *Intensive conditioning of forages*
- *Cold tolerance of alfalfa*
- *Ozone and alfalfa productivity*
- *Nondegradable proteins in the rumen*
- *Weed control in barley*
- *Wheat head blight*
- *Wheat midge*

Glenn Downing Prize from the CSAE Agricultural engineer and researcher Philippe Savoie, Ph.D., received the 1996 Glenn Downing Prize. This prize is awarded by the Canadian Society of Agricultural Engineering (CSAE) to those who have distinguished themselves in the areas of agricultural machinery and energy by their work in teaching, research, agricultural extension, or relations with the industry. Mr. Savoie meets all of these criteria since he

- teaches courses in the department of soils and agri-food engineering at Laval University
- sponsors graduate students
- conducts an agricultural machinery research project
- is the author of more than 150 scientific and interpretive articles
- has filed a patent that will enable a company to market one of his findings.

Nitrous oxide emissions from soils Frost and cultural practices can increase soil denitrification activity, the main process in N_2O emissions. Denitrification is greater in soil aggregates under rotation and minimum tillage than in soil aggregates under continuous cropping and ploughing. After frost, though, denitrification can increase up to 95% in aggregates where the two cultural practices are carried out. Denitrification also appears to be related to the quantity of mineralizable carbon.

Direct seeding and soil carbon The simplification of soil tillage improves the biological activity and carbon content of the soil's surface layer (0 - 10 cm) while maintaining crop yields comparable to those obtained under conventional plowing practices. An analysis of profiles (0 - 60 cm) of eight soils in eastern Canada showed, though, that direct seeding did not increase the carbon stocks of these soils. Soil tillage merely changed the distribution of organic residues in the soil profile.

Grain corn yield and pedological properties of soils The success of precision agriculture (PA) is based on a knowledge and understanding of the spatial variability of soils and crop yield within fields. The pH, which ranged from 5.4 to 7.2 in the field under study, is the property that best explains the variation in grain corn yield. The application of lime at variable rates is therefore the first PA strategy that should be implemented to improve and standardize fertilizer effectiveness and crop yield.

Soil structure and young organic matter Structure is a determining factor in the quality of agricultural soils. The use of the carbon-13 isotope showed the close link that exists between organic matter of recent origin and soil aggregation. The addition of fermentable organic matter helps to maintain the structural quality of soils.

Quebec soil names database A database containing all the names of soils used in 52 Quebec soil survey reports was developed. A total of 531 soil names were defined on the basis of 36 descriptors such as

- identification
- distribution
- status
- taxonomy
- characteristics of terrain
- soil family criteria.

This database represents a first step in correlating soils across the province and is a basic reference tool for standardizing research on Quebec soils.

Pedological reference framework for correlating soils In order to integrate, standardize, correlate, and synthesize soil information in southern Quebec, a territorial division was proposed in 5 provinces, 20 regions, and 45 subregions. The pedological subregions correspond to correlation areas, i.e., geographic zones in which each soil name is typical and almost exclusive.

Use of composts in cereal production Compost stimulates microbial activity and increases the water content of the soil under dry conditions. Commercial peat and manure composts or shrimp composts are of higher nutritive value to plants than farm manure composts. Inorganic fertilizer supplements must be added to composts to obtain higher cereal crop yields. To maximize efficiency, these composts are best applied in the fall preceding seeding.

Oxidation of soil organic matter An approach was developed to measure the oxidative losses of soil organic matter under a cover of corn. This technique is based on the difference in carbon-13 (^{13}C) content between C_3 - and C_4 -type plants. The methodology is based on the ^{13}C measurement of CO_2 in a soil developed under a C^3 -type vegetation in which corn is grown for the first time. The isotopic composition of CO_2 is used

- to calculate a simple mass balance
- to separate the total emissions of CO_2 on the soil surface depending on whether CO_2 originates in the rhizospheric respiration of corn or the decomposition of the soil organic matter.

Phosphorus in soil water drainage Preferential flow plays an important role in the mobilization of phosphorus after a period of low rainfall. The diffuse flow appears mainly in the form of organic phosphorus. The ratio of the quantity of phosphorus extractible with ammonium acid oxalate to the amounts of aluminum and iron extractible with the same solution can be used to predict the mobility of phosphorus in soils whose fixation capacity varies.

Intensive conditioning of forages Highly intense mechanical conditioning of forages, commonly called intensive conditioning, consists of crushing fresh grass at mowing. The process reduces curing time in the field before alfalfa is transported for dehydration and cubing. This method also appears to increase the product's quality. Very encouraging results were noted relating to

- voluntary consumption of forages by animals
- milk production
- growth of ruminants fed intensive-conditioned forages.

Cold tolerance of alfalfa Accumulation of the cryoprotective sugars raffinose and stachyose in alfalfa varies greatly. A nondestructive method of selecting genotypes for the accumulation of higher levels of these sugars was developed. By analyzing genetic expression changes in alfalfa during cold hardening under winter conditions, scientists identified a group of proteins whose composition is related to the degree of cultivar hardiness.

Ozone and alfalfa productivity Chronic exposure to ozone leads to a marked increase in alfalfa growth. Analyzing the response of alfalfa genotypes allowed scientists to identify genotypes possessing the ability to maintain their productivity after exposure to an ozone-enriched atmosphere.

Nondegradable proteins in the rumen The level of nondegradable proteins in roasted soybeans may be predicted by using near-infrared spectroscopy. This system revealed that 70% of the 266 samples of soybeans roasted commercially or on the farm were inadequately heated.

Weed control in barley Reducing spacing between rows in barley does not affect the aerial biomass and number of stems of quack grass in the seeding year or the year following harvest of the cereal. Quack grass can be reduced by high seeding rates. The quack grass population, though, remains relatively small.

Wheat head blight AC Voyageur, the variety of bread wheat tolerant to head blight, developed at the Sainte-Foy Research and Development Centre and licensed in 1994, has shown much fewer symptoms than susceptible varieties subject to intense natural inoculation. The same is true of the bread wheat varieties AC Brio and AC Napier. These varieties, tolerant to head blight, were developed at the centre and will be licensed shortly in Canada.

Wheat midge Fourteen fields of wheat (*Triticum aestivum*) from various agricultural regions in Quebec were sampled once or twice in July and August 1995. The larva of the wheat midge was present in all lots observed in a proportion of 2 - 98% of heads. An average was noted of

- 0.04 - 13.76 larvae per head
- 0.002 - 0.855 larvae per spikelet.

Head infestation by wheat midge larvae is related to grain bacterial and fungus contamination. There is also a relation between the presence of *Fusarium graminearum* in wheat kernels and the number of larvae per head and per spikelet. Yield losses attributed to wheat midge were estimated at 6%.

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Mandate

The Dairy and Swine Research and Development Centre in Lennoxville improves

- the productivity and profitability of dairy and swine production for Canada
- sheep and beef cattle production for eastern Canada.

Resources

The research centre staffs 102 full-time equivalents, including 24 scientists. It has a total budget of \$7.5 million, including funding for the Matching Investment Initiative and other special projects. The centre manages

- 400 ha and 350 dairy cattle at Lennoxville
- 370 ha and 250 beef cattle at Kapuskasing.

Achievements

- *Chemical composition of rumen bacteria*
- *Feeding of high-moisture wheat to dairy cattle*
- *Use of folic acid by calves*
- *Protein metabolism in cattle*
- *Fear of humans in cows*
- *Sucking motivation of calves*
- *Folic acid, prolificacy, and embryo survival in swine*
- *High-fiber diets for pregnant sows*
- *Less polluting pig feeds*
- *Applied net-energy system and mathematical modeling of meat-type pigs*
- *In vivo evaluation of the body composition of swine*
- *Treatment of liquid pig manure*
- *Canola meal*
- *Productivity of hybrid ewes*
- *Estrus synchronization of ewes*
- *Estrus synchronization of cattle*

Chemical composition of rumen bacteria Rumen bacteria constitute a significant source of nutrients for ruminants. Currently, ration-formulation calculations that take this into account consider only the contribution of the bacterial fraction associated with the liquid phase of the rumen (BAL). Researchers observed that the chemical composition of bacteria associated with the solid phase (BAS) differed from that of BAL. Since BAS represent a significant fraction of rumen bacteria and their chemical composition differs from that of BAL, their inclusion in calculations could have a major impact on the formulation of rations fed to ruminants.

Feeding of high-moisture wheat to dairy cattle Cows receiving a high-moisture wheat supplement as opposed to a high-moisture corn supplement had higher production of milk corrected to 4% fat. The cost of the wheat supplement is also less than that of corn. Furthermore, the use of high-moisture wheat presents an attractive alternative in areas unsuitable for the growing of corn, since wheat does not require as long a growing season as corn.

Use of folic acid by calves The tissue demand for folic acid increases with age during the first 4 months of life of preruminant and ruminant calves. Folic acid supplements augment the folate saturation of tissues but do not fully meet tissue demand. This increase in the tissue demand for folic acid is probably due to the faster growth of calves fed folic acid supplements during the study period. The results agree with the growth trials carried out earlier, which showed the positive effect of folic acid supplements on the growth of veal calves and weaned calves.

Protein metabolism in cattle Researchers developed a technique for estimating the various compartments of protein metabolism in cattle using markers enriched with carbon-13, a stable nonradioactive isotope. The proteins synthesized by the animal and ultimately consumed by humans, such as milk and meat, are the result of two concomitant physiological processes, i.e. the synthesis and degradation of proteins. To optimize protein production for human consumption, each of these processes must therefore be quantified in order to target the critical points where steps may be taken to improve the final result.

Fear of humans in cows Cows and calves quickly learn to distinguish between humans who treat them well and humans who don't. Clothing color is the main signal cows use for distinguishing between people. Researchers developed techniques and tests to measure fear in cows. To evaluate the effects of fear on the productivity and well-being of cows, they quantified the animals' physiological and behavioral responses in situations where the fear caused by humans comes into play. Researchers will thus be able to develop enlightened recommendations on ways of avoiding the harmful effects of fear.

Sucking motivation of calves Calves fed milk have high sucking motivation. The ingestion of milk stimulates this motivation. Non-nutritive sucking following the feeding of milk increases the secretion of digestive hormones. These results show the importance of sucking for calves. Researchers recommended that calves be given a non-nutritive teat after a meal of milk to improve their well-being.

Folic acid, prolificacy, and embryo survival in swine Folic acid supplements induce increased secretion of uterine prostaglandins and accelerate embryo development at the beginning of gestation in sows. These results agree with the beneficial effect of this vitamin on embryo survival and prolificacy, which researchers already observed.

High-fiber diets for pregnant sows When pregnant sows were fed a high-fibre diet, researchers observed a reduction in

- hunger
- feed motivation
- stereotyped behaviors.

These positive effects increased with the percentage of incorporation of fibers in the diet and were closely related to the lengthening of feeding time. High-fiber diets characterized by an inadequate amount of energy, though, increased stereotypies before meals, thus confirming that nutritional intake is also an essential factor in relation to satiety.

Less polluting pig feeds The excretion of toxic elements, including nitrogen, may be controlled by balanced feeding adapted to the needs of swine. Researchers developed a new method of formulating rations that simultaneously reduces the price of the formula and the quantity of nitrogen irreversibly excreted by feeder hogs. This multiobjectives method, based on the usual formulation algorithm (simplex), could help to solve problems associated with surplus effluents in hog production. In 1995, researchers established that the use of this method would have reduced the total protein excreted by an average of 43% in Quebec and 67% in France, with the cost of mixing feeds increasing by only 2.3% and 4.8%, respectively.

Applied net-energy system and mathematical modeling of growing pigs Net energy (NE) systems take into account differences between nutrients in terms of their digestible energy (DE) efficiency. Based on these principles, a new NE system was developed that can be incorporated into a mathematical pig growth model. This NE system can predict how the protein and fat deposits of growing pigs will be affected by

- the change in the ration's nutrient composition
- the feeding level
- the physiological stage
- the genetic potential for protein growth.

The model was calibrated and validated on the basis of the fat retention predictions in experiments simultaneously measuring the production of heat in a fasting state and protein and fat retentions.

In vivo evaluation of the body composition of swine By evaluating the body composition of feeder hogs, it is possible to determine their growth in protein and fat. This analysis is essential to

- optimize the leanness of carcasses and slaughter weight
- formulate rations adapted to animal requirements
- control the toxicity of manure.

Our results clearly showed that ultrasound equipment (unidirectional or real time mode) can estimate protein and fat mass in live animals with good accuracy. The best predictions of the body composition of swine were obtained, though, with the Lunar X-ray scanner.

Treatment of liquid pig manure Various antibiotics are regularly added to pig feed to promote growth or control disease. Many of these antibiotics are excreted in the urine and feces. The presence of antibiotics in liquid pig manure has no negative effect on the microorganisms of anaerobic bioreactors. These bioreactors are used to treat liquid pig manure in order to make it odorless and reduce its organic pollutant load by 76% or more.

Canola meal Heat treatment reduces the level of rapidly degradable proteins of canola meal in the rumen. The use of molasses with steam is the process that reduces treatment time the most.

Productivity of hybrid ewes Hybrid Romanov × Suffolk and Romanov × Dorset ewes have similar breeding performances. The quality and performance of lambs from these two types of females differ mainly depending on the breed of the terminal ram. Hampshire rams had better results than Suffolk for growth parameters.

Estrus synchronization of ewes In an estrus synchronization treatment with prostaglandins ($\text{PGF}_{2\alpha}$) in the prolific breed Arcott Outaouais, GnRH should not be injected until 48 h after the second injection of $\text{PGF}_{2\alpha}$ in order to maximize fertility. The GnRH injection protocol should be revised on the basis of the prolificacy of the breed used.

Estrus synchronization of cattle Researchers developed a new method of estrus synchronization using two hormones:

- gonadotrophin-releasing hormone (GnRH)
- prostaglandin $\text{F}_{2\alpha}$ (PGF).

This program (GnRH-PGF) synchronizes heats over a shorter period (4 days). The GnRH-PGF method increases the effectiveness and accuracy of estrus synchronization in beef cows without affecting their fertility. GnRH treatment (day 0) 6 days before injecting PGF (day 6) to induce luteolysis

- blocks heats for 6 days preceding PGF treatment, thus eliminating the necessity to detect heats during this period
- makes it possible to synchronize approximately 80% of females in heat during a period of less than 4 days without any reduction in fertility, as a result of the synchronization of emergence of a new follicular wave.

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Mandate

The Horticulture Research and Development Centre develops environmentally sustainable techniques and systems of production for

- vegetables
- fruits
- ornamentals.

Resources

The centre manages 75 full-time equivalents including 20 scientists. Its total budget of \$5.4 million includes funding for the Matching Investment Initiative and other special programs. The centre is also responsible for L'Assomption Research Farm (80 ha) and field sites at

- Lavaltrie (25 ha)
- Frelighsburg (134 ha)
- L'Acadie (86 ha)
- Sainte-Clotilde (32 ha).

Achievements

- *Staff awards and honors*
- *R & D cost-sharing program*
- *New strawberry cultivar*
- *Stimulo-repellent odor and the cabbage maggot*
- *Parasitoids and biological control*
- *Chitin-urea and soil nematodes*
- *Entomopathogenic fungus and lady beetles*
- *Obliquebanded leaf roller*
- *Effects of neem on predators*
- *Isomate-C for control of the codling moth*
- *Mycorrhizae and herbicides*
- *Rational use of herbicides*
- *Foliar surface and weed management*
- *Weed seed stock*
- *Air-assisted spraying*
- *Hardiness potential of ornamentals*

Staff awards and honors The Departmental Committee awarded an Agcellence-Leadership Award to Claude Richer, M.Sc., for her initiative in establishing the Quebec Ornamental Woody Plants Testing Network (REPLOQ). The network includes a dozen partners from the federal and provincial governments, universities, and private sector nurseries.

Denis Demars, Ph.D., Director, received the Agcellence-Innovation Award for his contribution to the team headed by Mr. P.A. O'Sullivan, Ph.D., of Saskatoon, for the development of a new study management system. Designed to be more efficient, more objective, and more precise than previous methods of research management, the new system will provide optimum utilization of resources devoted to priority research.

R & D cost-sharing program In 1996, 29 new agreements were signed, involving 14 researchers and an investment of \$2 082 714 by private sector collaborators. Agriculture and Agri-Food Canada matched this investment. Some projects started this year will continue until 2001. Since the program was established in April 1994, the HRDC has signed nearly 70 research agreements with producers, producer groups, and private firms for an investment totaling over \$6 million.

New strawberry cultivar Joliette is a new strawberry cultivar selected in collaboration with Macdonald College of McGill University. It is a hardy midseason cultivar comparable to Bounty, Glooscap, Honeoye, and Kent. It has good resistance to

- the principal foliar diseases such as leaf scorch and leaf spot
- red stele, which attacks the plant roots.

Joliette is currently under evaluation in other provinces and in Germany, Switzerland, Belgium, and Russia. It will be multiplied by authorized nurseries in Canada and distributed under license in Europe and the United States starting in the spring of 1998.

Stimulo-repellent odor and the cabbage maggot A team of entomologists extracted a biological product for control of cabbage maggot populations. They used *Aleochara bilineata*, an adult-stage predator and larval-stage parasitoid of the cabbage maggot. The product acts on the communication system of the insects, so that they misjudge the population density of maggots in the fields under control. Unlike conventional insecticides, the product is specific and has no negative effect on the natural enemies of cole crop pests. The product also acts at several levels on various insects, which minimizes the risks of development of resistance.

Parasitoids and biological control The parasitoid *Peristenus digoneutis*, introduced to New Jersey from Europe, is being used as a biological product for control of the tarnished plant bug in alfalfa. Before determining its effectiveness and survivability under Quebec's climatic conditions, researchers studied the insect's life cycle. They now know that the egg laid in the tarnished plant bug pupa takes 5 days to hatch, producing a larva that will go through three instars before emerging from its host after about another 12 days. The larva then weaves its cocoon and the pupa develops for 2 weeks before diapausing for a period of 8 months. The studies are continuing to determine the insect's potential in controlling the tarnished plant bug in horticultural crops in Quebec.

Chitin-urea and soil nematodes In a greenhouse experiment, researchers measured the effectiveness of a chitin-urea amendment in controlling root-knot nematodes in tomatoes grown on organic soil. An increase in the number of nematode eggs was observed in the presence of chitin-urea. At harvest, the weight of the tomatoes was not affected by the presence of the nematode or the chitin-urea. The addition of chitin-urea at the rates studied did not reduce the nematode populations present before planting.

Entomopathogenic fungus and lady beetles Researchers evaluated the effect of *Beauveria bassiana* on the development of larvae and pupae of the twelve-spotted lady beetle, *Coleomegilla maculata lengi*, a polyphagous predator. Pollen or larvae of the Colorado potato beetle (*L. decemlineata*) were treated with each of two races of the fungus before being presented as food:

- ATCC 44860
- ARSEF 2991.

Although the two races are also toxic to the Colorado potato beetle, they have a very different effect on the development of larvae and pupae of the twelve-spotted lady beetle. The race ARSEF 2991 was very toxic, while the race ATCC 44860 had a very negligible effect. Other studies are necessary to measure the predation effectiveness of the lady beetles, whose development slows in the presence of *Bassiana* sp. in the environment.

Obliquebanded leaf roller A major apple pest, *Christoneura rosaceana* or the obliquebanded leaf roller (OBL), has developed resistance to synthetic insecticides over the years. A recent study showed that extracts of neem, *Azadirachta indica* A. Juss. (Meliaceae), are very toxic to OBL, causing

- slower growth of larvae
- a reduction in the pupa hatching rate.

Adults emerging from pupae formed by treated larvae exhibit major physical malformations and a low reproductive capacity. The use of neem-based products make an attractive alternative in an integrated pest management program for control of the oblique-banded leaf roller because it offers

- a high degree of toxicity
- a mode of action different from that of commonly used synthetic insecticides
- few observable effects on most beneficial insects.

Effects of neem on predators Certain compounds contained in neem oil act as repellents or prevent feeding in the case of several phytophagous insects. A recent study shows that neem acts in the same way on lady beetles as it does on aphids. Natural insecticides, like synthetic insecticides, should be carefully used when it comes to developing an integrated pest management program aimed at reducing the use of synthetic insecticides so as to promote beneficial insect fauna.

Isomate-C for control of the codling moth In Quebec, apple growers who apply so-called biological production management can count on the use of synthetic pheromone dispensers for control of the codling moth. Under the climatic and cultural conditions of Quebec orchards, the Isomate-C dispenser, developed and used by growers in British Columbia, gave excellent results in orchards with medium and low insect populations. Where orchards are larger than 2 ha and are located on fairly flat land, this method represents a further step in the development of a control program having minimum negative effects on

- users
- crops
- consumers
- the environment.

Mycorrhizae and herbicides In a greenhouse trial, two groups of apple seedlings, one infected by mycorrhizae and the other not, were subjected to the action of the herbicides

- simazine
- dichlobenil
- paraquat.

Response to the herbicides was much greater in the case of the mycorrhiza-infected plants, and their rate of growth was considerably reduced. Although none of the herbicides affected the colonization of roots by mycorrhizae, the elongation of mycorrhiza hyphae was reduced by dichlobenil and paraquat. Hypha elongation was not influenced, though, by simazine. Because plant mortality was higher in the mycorrhiza-infected plants, it is important to take these results into account, especially for crops that benefit from mycorrhizae, such as dwarf apples.

Rational use of herbicides In grain corn, early post-emergence application of herbicides in bands over the row (40% of cultivated area) combined with two selective mechanical weeding over the entire area 2 - 4 weeks after crop emergence represent an alternative to the intensive use of herbicides. This was a finding in research carried out in 1991 and 1992 in grain corn crops in Quebec. The yields obtained by weeding the fields under this method were equivalent to those obtained when herbicides were applied over the entire cultivated area.

Foliar surface and weed management To carry out integrated pest management based on weed damage thresholds, two forecasting models were compared. The study showed that for white mustard (*Sinapis alba* L.), the model based on the relative foliar surface of this weed gave a better evaluation of the situation than the hyperbolic model based on the weed's density. Because of the great variability in results between sites and crop years, the model still requires several adjustments before being incorporated into an integrated weed management program.

Weed seed stock In an alternating corn - soybeans production system, the effect of four types of soil preparation was evaluated in relation to weed seed production and the composition of the seed stock, especially that of lamb's-quarters, in the soil. The stock of lamb's-quarters seed, which represents 50% of the total, was higher under conventional plowing than under

- chisel plowing
- ridge seeding
- direct seeding.

For direct seeding and chisel plowing, more than 60% of the weed seed stock is in the first 5 cm of soil. Under conventional moldboard plowing, distribution occurs in greater depth. Lamb's-quarters and similar species produce more seeds per unit area under conventional and chisel plowing. In ridge-seeded and direct-seeded corn - soybean production systems, these same species produce fewer seeds. These results therefore seem to indicate that the weeds would be easier to control in such systems.

Air-assisted spraying Confronted with the problem of protecting crops against pests while protecting the environment against pesticide drift, a research team tried to optimize plant coverage (top and bottom of leaves) and product penetration on plants (top and bottom of plant) based on spraying conditions, namely:

- velocity
- volume
- angle of air discharge.

These trials were carried out in broccoli and potato crops. By using a fine spray nozzle with air at high speed (greater than 25 m/s) and at high volume (0.9 m³/s per metre), the product was well distributed on the upper and

lower surfaces of the leaves and from top to bottom of the plant. At a lower speed (less than 20 m/s), only the upper surfaces of leaves at the top and middle of the plant were covered.

Hardiness potential of ornamentals The hardiness rating of ornamental shrubs must be ascertained to determine their actual potential based on

- survival
- flowering
- fruiting
- foliage texture or coloring
- habit
- shape.

Researchers responsible for the Quebec Woody Plants Testing Network (REPLOQ) checked this aspect by characterizing the potential for survival, use, and full ornamental expression of seven ornamental shrubs under climatic conditions corresponding to hardiness zones 2 - 5 of the Canadian system defined by Ouellet and Sherk (zone 5 being the least harsh climatic zone). As a result of the evaluation, the area suitable for establishing these ornamental shrubs in Canada was expanded.

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Mandate

The Food Research and Development Centre in Saint-Hyacinthe helps Canada's food industry become more competitive by conducting research in the area of food processing. The centre also promotes the development and transfer of new technologies, by

- providing a technological environment
- making scientific and technical staff available to the food and beverage industry for the implementation of its research and development projects.

Resources

The centre uses a wide range of specialized, modern instruments to carry out research and has pilot plants with equipment specially designed for developing new products. The centre shares its premises with some employees of the Food Technologies Service of the Quebec Department of Agriculture, Fisheries and Food and a technical adviser of the National Research Council of Canada. In 1996 - 97 the centre began with 76 full-time equivalents and employed 31 scientific staff. Its budget totaled approximately \$7 million, including funding for the Matching Investment Initiative and other special programs. Through the Matching Investment Initiative and staff redeployments over the course of the year, the centre added an additional \$3 million and 17 full-time equivalents to its resources.

Achievements

- *Industry services*
- *Business initiative and communications*
- *Francophone program*
- *Visual evaluation of the color of meat products*
- *Meat spoilage*
- *Flavor release*
- *Fermentation of yeast extracts*
- *Propionic acid on whey*
- *Continuous inoculation of cheese milk*
- *Recombinant enzymes for the dairy industry*
- *Production of oligonucleotides*
- *Packaging of soft cheeses*
- *Ohmic heating*
- *Baking of pastry products*
- *Electroacidification of soybean proteins*
- *Vitamin E in plastics*
- *Packaging of fruit beverages*
- *Measurement of flour quality*
- *"In-package" cooking of meats*
- *Films for controlled release of antimicrobial agents*
- *Coating and packaging of tomatoes*
- *Coating for preserving strawberries*
- *Storing blueberries*
- *Light Cheddar cheese*
- *Third-generation yogurts*

Industry services One of the major attractions of the Food Research and Development Centre is that it allows the industries themselves to carry out research in pilot plants. A total of 104 confidential industrial projects, involving 100 companies (including 64 new ones), were carried out in 1995. This arrangement allows

- a high level of confidentiality
- rapid technology transfer into production.

Business initiative and communications The centre has established a structured approach to the selection of companies, with which it negotiates the use of R & D results and the protection of intellectual property. A major update to its standard agreement for scientific collaboration with the private sector was made

- to allow for the recovery of the centre's contributions in the case of commercial or industrial successes
- to cover the aspect of co-patent filing.

The centre coordinated numerous knowledge-transfer activities for technical and commercial staff in the food industry. In collaboration with the Fondation des gouverneurs, it developed an Information Centre project. The funding research and project planning are completed, and construction will begin in November 1996.

Francophone program The objective of the program is to support the establishment of small and medium-sized agri-food industries in developing Francophone countries. The year was marked by the development of the course "Technical and Commercial Development of Small and Medium-Sized Agri-Food Industries", offered in Morocco and Haiti. A reference book entitled *L'entreprise agroalimentaire : assurer la croissance* was produced for the occasion. The centre welcomed many foreign delegations, including a group of trainees from Haiti. The centre is also involved in a fruit-valorization project in the Ivory Coast, in collaboration with Geomar International.

Visual evaluation of the color of meat products The color of cured meat products may be finely evaluated by observing digitalized images of products on a high-resolution color screen. This new method will be a valuable tool in analyzing organoleptic changes produced by cooking or occurring during storage.

Meat spoilage Of 23 known antimicrobial agents, acetic, lactic, propionic, lauric, palmitoleic, linoleic, and linolenic acids, and the essential oils of clove, cinnamon, and rosemary were found to be the most effective in retarding the most common meat spoilage bacteria belonging to the genera

- *Brochothrix*
- *Carnobacterium*
- *Lactobacillus*
- *Pseudomonas*
- *Serratia*.

Flavor release The study of flavor release covered four separate types of analyses:

- effectiveness of mastication in terms of particle size after mastication and extraction of soluble substances
- quality of the buccal apparatus in relation to food crushing capacity
- sensory perception in relation to time
- interest in tasting a food.

The statistical analysis showed the link between all of these factors.

Fermentation of yeast extracts The propionic fermentation of yeast extracts (YE) was done to produce

- YE with natural preservatives
- agents having a Swiss cheese flavor.

Little growth of *Propionibacterium* occurred in 10% YE solutions, which prompted researchers to use 7% solutions and a fermentation technology with immobilized cells. The fermented YE were dried and used in bread making. The YE with propionate helped to reduce the growth of fungus contaminants on bread but did not affect the fermentation of bread.

Propionic acid on whey A 10-L radial-flow bioreactor was tested for the production of propionic acid on whey permeate. At a dilution rate of 1 L/h ($D = 0.1/\text{h}$), the complete fermentation of substrates took place. A contaminant flora developed in the system, however.

Continuous inoculation of cheese milk In collaboration with the Centre STELA of Laval University, the effect of phage contamination on the behavior of a bioreactor used for the continuous inoculation of cheese milk was studied. Bacteriophages developed in the bioreactor, even at very high dilution rates ($D = 30/\text{h}$). Changes in flora (proportions of lactococci sensitive or resistant to phages) occurred more slowly in the immobilized-cell bioreactor than in conventional free-cell systems.

Recombinant enzymes for the dairy industry Peptidases of *L. casei* responsible for cheese ripening, which make protein hydrolysates less bitter, were over-expressed. The lactases (β -galactosidases) of *S. thermophilus* and *K. fragilis*, which can hydrolyze lactose and synthesize galactooligosaccharides (nutraceuticals), were also over-expressed. The scaling-up of production of both classes of recombinant enzymes is under way, with the participation of industries interested in their marketing.

Production of oligonucleotides A large quantity of flavoring ribonucleotides (5'-IMP and 5'-GMP) was produced through fed-batch fermentation of whey using *Kluyveromyces fragilis*. Other oligonucleotides that have been produced could be used as therapeutic (immunostimulant and antiviral) agents for humans and animals.

Packaging of soft cheeses Two innovative packaging concepts were developed to slow the ripening of soft cheeses. The modeling of cheese - packaging interactions is completed. This major project is in the industrial preproduction stage.

Ohmic heating Two units for ohmic heating were recently installed at the centre. The laboratory static unit allows the evaluation of heating time for liquid food products, solids, and mixes of liquid and food pieces. The other unit, a pilot, is continuous. It allows simulation of an industrial process. Ohmic heating is an extremely fast technique, which generates heat when an alternating current passes through food that has electric resistance. Work is now being done in collaboration with the College Macdonald of McGill University.

Baking of pastry products A Canadian company has invested in the construction and validation of a pilot oven capable of reproducing the industrial baking conditions for pastry products in more than 20 tunnel ovens. The Electrochemistry and Electrotechnologies Laboratory of Hydro-Quebec is also a partner in the pilot stages of oven design.

Electroacidification of soybean proteins In collaboration with the Electrochemistry and Electrotechnologies Laboratory of Hydro-Quebec, researchers optimized the soybean protein electroacidification process, an electro dialysis application using bipolar membranes. This process is an attractive alternative to the conventional coagulation process requiring the use of a strong acid and a strong base. In addition, the proteins produced from electrocoagulation are not denatured.

Vitamin E in plastics Materials containing vitamin E were used for the packaging of a processed product obtained from organic vegetables. This type of material adds value to the food while limiting the effects caused by the migration of chemical antioxidants from the plastic to the food.

Packaging of fruit beverages In collaboration with the Industrial Materials Institute of the National Research Council of Canada, several projects were carried out to optimize the packaging of fruit juices and beverages. Research focused on the forming and nature of the polymeric resins used. The physical and chemical properties of the materials obtained were measured to determine the quality and shelf life of the packaged juice.

Measurement of flour quality In collaboration with the Cereal Research Centre (Winnipeg, Agriculture and Agri-Food Canada), a new technique was developed to rapidly determine the bread making ability of new wheat cultivars. The technique consists of weakening the dough structure through excessive fermentation. The dough is then subjected to a physical shock. This simple method is applicable for small or large quantities of flour, whether used for the production of frozen dough or not.

“In-package” cooking of meats A study of the effects of ham-cooking parameters on the permeability properties of plastic materials used for “in-package” cooking showed that heat treatment, the presence of water, and contact with the ham bring about an increase of more than 500% in the rate of transmission of oxygen from these materials. As a result, the material lost its barrier properties, thus reducing ham storage life.

Films for controlled release of antimicrobial agents Various formulations of polysaccharides with added substances containing antimicrobial properties were developed. This work was done in collaboration with

- the centre’s Meat Products Section in the case of meats
- an industrialist, importer, and trainees from Paris VI University in the case of mangoes.

Coating and packaging of tomatoes Natural chitosan or cellulose-based films with added lipids were developed for modified-atmosphere packaging of tomatoes.

Coating for preserving strawberries A chitosan and lipid-based coating was developed to create a modified atmosphere in strawberries at room temperature. At refrigeration temperature, the internal gas composition of the fruits returns to normal. This development was carried out with the participation of the Department of Energy of Canada.

Storage of blueberries Blueberries picked in the Lac Saint-Jean district were studied under cold and modified atmosphere storage. Various mathematical models were developed for the analysis of respiratory rates. The best storage conditions for slowing spoilage reactions and preventing fruit fermentation were determined.

Light Cheddar cheese Microfiltration (MF), a new membrane-separation process, concentrates milk caseins. Its potential was evaluated for the production of light Cheddar-type cheeses. Cheeses were thus manufactured from cheese milk enriched with 3, 4, 5, and 6% caseins, using various sources of powdered casein concentrates, such as

- ultrafiltration (UF) concentrate
- MF concentrate
- calcium caseinate (CNCa).

The composition of UF and MF cheeses was slightly different from that of CNCa cheeses. The cheese yields and rate of fat recovery was higher in UF and MF cheeses than in CNCa cheeses. During ripening (3 months), proteolysis was similar for all cheeses. The MF concentrate can therefore be used to produce light Cheddar-type cheeses.

Third-generation yogurts The dairy microbiology research group developed many procedures useful to industries interested in verifying the quality of their yogurts and fermented milks enriched with bifidobacteria and lactobacilli of the acidophilus or casei groups. Selective culture media were developed to count bifidobacteria in the presence of yogurt cultures. The bifidobacteria and lactobacilli were identified by using

- genetic probes
- DNA-DNA hybridization for nonradioactive labeling
- polymerase chain reaction (PCR) tests
- random applied polymorphic DNA (RAPD) tests.

The RAPD technique differentiates the various species of bifidobacteria and lactobacilli. The use of five primers of nucleotides led, after amplification, to the generation of specific profiles for each species. This technique is currently used for characterization of banks of industrial strains.

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Mandate

The Pest Management Research Centre at London

- develops alternative and environmentally acceptable technologies for the protection of tree fruits, vegetables, and field and ornamental crops from disease and insect pests
- develops alternative crops and sustainable management practices for coarse-textured soils
- determines the impacts of agricultural practices on soil and water quality.

Resources

The centre employs 143 full-time equivalent staff members, including 40 scientists. It has a combined land area of 111 ha and manages a budget of \$8.8 million.

Activities are conducted at three locations. The main centre is on 25 ha on Sandford Street in London and at the Siebens Drake Research Institute at the University of Western Ontario. The centre also includes

- Delhi Research Farm (60 ha)
- Vineland Research Farm, located on the provincial research station property in the Niagara Peninsula, with a 26-ha field site located 3 km from the research farm.

Achievements

- *Integrated control of greenhouse insects and diseases*
- *Food-grade oils for fungal control*
- *Control of crown gall in grape*
- *Pesticide resistance in the Oriental fruit moth (OFM)*
- *Imported natural enemies of Lygus plant bugs*
- *Molecular markers for biological control agents*
- *Sensitivity of Prunus rootstocks to root-lesion nematode*
- *Alternative control methods for nematodes*
- *Biocontrol of bacterial diseases of tomato*
- *Regulation of bacterial phytotoxin synthesis*
- *Development of biopesticide tools*
- *Insect pest control and pesticide persistence*
- *Plant disease control*
- *Organic amendments to soil*
- *Herbicide-induced disease resistance*
- *Stevia*
- *Ginseng*
- *Flue-cured tobacco*
- *Soil porosity and soil biological activity*
- *Pesticides and biological activity in soils*
- *Tillage practices and biological activity in agricultural soils*
- *Nitrogen management on coarse-textured soils*

Integrated control of greenhouse insects and diseases Behavior of the western flower thrips can be monitored to enhance its control in greenhouses. Trap cards record flight rhythms and dispersal patterns. This information is correlated with damage and thrips populations to determine when to apply sprays for optimum control. Most pesticides are less effective than predicted on the basis of toxicological data. Analysis of pesticidal effects on thrips behavior explains why this is so. Use of behavioral data improves spray timing to increase the effective period of pesticide residues for controlling thrips.

Inert food-grade products were identified for controlling thrips both on and off plants. These products are not a hazard to workers, the environment, or the consumer. They will be substituted for toxic pesticides and may be compatible with biocontrol agents.

Food-grade oils for fungal control For the control of grapevine powdery mildew, mineral oils were

- better than plant oils
- comparable to synthetic fungicides.

They inactivated established infections and reduced spore production. In programs of four or five sprays, the oils did not affect yield, but they may have reduced fruit sugars when combined with a certain ethylene-bis-dithio-carbamate fungicide. A food-grade mineral oil reduced botrytis bunch rot of Chardonnay grapes and could be of value in a grape integrated pest management program.

Control of crown gall in grape This disease (*Agrobacterium vitis*) is a major problem for the industry. Heat-treatment trials with both dormant and 1-year grafted nursery stock show some promise. Large-scale commercial testing was done at several field sites in the United States and Ontario. A hybridization assay is being developed for the rapid and sensitive detection of *A. vitis* in grapevine. It will be substantially less expensive and have similar sensitivity as the currently used polymerase chain reaction assay.

Pesticide resistance in the Oriental fruit moth (OFM) A bioassay technique for OFM moths successfully monitored resistance to organophosphate and pyrethroid insecticides in field populations in large plots. Results:

- Long-term or seasonal rotations of insecticides were most useful in minimizing numbers of moths resistant to both groups of insecticides.
- Alternation of insecticide groups for one of the three generations also reduced survivor numbers.
- Surveys of several commercial orchards that used season-long pyrethroid programs for 2–2.5 years show increasing numbers of moths surviving discriminating doses. These sites have not yet reported reduced crops.

Imported natural enemies of *Lygus* plant bugs Centre staff made collections during a transfer of work to the European Biological Control Laboratory of the US Department of Agriculture in France, in collaboration with

- International Institute of Biological Control, Switzerland
- Hungarian Plant Protection Agency.

The collections from central Europe provided 1550 diapausing parasitoid cocoons to establish imported parasitoids for potential control of mirid bugs in Canada. Mirid bugs, such as *Lygus lineolaris*, develop on a variety of plant hosts then invade orchard crops as winged adults, causing damage and provoking costly insecticide treatments that disrupt integrated pest management programs.

Molecular markers for biological control agents Collaboration with Institut National de Recherche Agricole, Centre de Recherche nationale Scientifique, and the University of Montpellier II has resulted in the genetic characterization of an important predator of spider mites, the phytoseiid mite, *Amblyseius fallacis*. The characterization has been used to follow under different pesticide regimes the establishment and survival of a resistant strain released in a 4-hectare apple orchard. The research provides information for practical guidelines on the release of natural enemies.

Sensitivity of *Prunus* rootstocks to root-lesion nematode Eleven rootstock varieties and lines of *Prunus* were compared for sensitivity to the root-lesion nematode *Pratylenchus penetrans*, in cooperative greenhouse trials between the centre and the Ontario government. Experimental results showed differences among rootstocks in the extent of nematode multiplication; Chui Lum Tao variety supported the smallest number of root-lesion nematodes, whereas the line BY 520-9 supported the most.

Alternative control methods for nematodes A team of chemists and nematologists are collaborating with industrial partners to develop novel products with nematicidal activity. This work is in anticipation of the withdrawal of several currently-registered nematicides. *Tagetes* marigolds has been found useful as an alternative to chemical fumigation. It is a nematode-suppressing and biomass-producing rotational crop.

Biocontrol of bacterial diseases of tomato Three microbial biocontrol agents from the United States were field-tested for the ability to reduce symptoms on plants infected with bacterial speck or bacterial spot. Two strains significantly reduced the severity of bacterial speck:

- *Pseudomonas fluorescens* A506, registered for fireblight biocontrol in the United States
- the pseudomonad Cit7.

Cit7 also had a pronounced effect on the bacterial spot pathogen. Neither strain enhanced the fruit yield of infected plants or reduced disease severity on spot-infected pepper plants. These results not only demonstrate the potential for developing a biocontrol strategy for bacterial speck and spot, but they also indicate the need to identify biocontrol agents uniquely adapted to Ontario field conditions.

Regulation of bacterial phytoxin synthesis Coronatine is a potent phytoxin produced by the *Pseudomonas syringae* pathovars that infects

- stone fruits
- tomatoes
- crucifers
- soybeans.

Bacteria that have lost the ability to produce this inducible toxin cause little crop damage. Therefore targeting toxin synthesis may be an effective means of controlling these pathogens.

Cor::inaZ reporter fusions were used to examine the effect of leaf extracts and various common plant constituents on coronatine gene expression. The following compounds stimulated toxin synthesis:

- sugars
- glucose
- galactose
- sucrose
- organic acids
- citric
- malic
- succinic
- quinic
- shikimic.

Quinic and shikimic acids were the only compounds active at concentrations of 100 *M* or below. An assay was developed for identifying substances that suppress gene induction by these compounds.

Development of biopesticide tools Myosuppressins are small neuropeptides that can strongly inhibit muscle contraction in insects. Genes encoding for these peptides have been isolated from the brains of two different insect species, and the DNA sequences of the resulting clones determined. These genes are now being cloned into baculovirus vectors to test whether their expression can improve the activities of the viruses for use as biopesticides.

We have synthesized analogs of the peptide HVFLRFamide, a structural element common to all the myosuppressins, and the minimum amino acid sequence that exhibits inhibitory activity on insect muscle. Features of the histidine moiety necessary for activity were defined. This work is the first step toward the development of pseudo- or non-peptide mimics that have potential as novel pest control agents.

In field studies in 1995, a genetically modified baculovirus declined in activity with passage through successive populations of insect pests. This result was attributed to lower yield potential of the recombinant compared with the wild-type baculovirus. It may model the field behavior of genetically enhanced baculoviruses. Laboratory studies are now determining virus production and transmission capacity of a baculovirus carrying an insect-specific toxin gene.

We have determined the degree of inhibition of Colorado potato beetle gut proteinases required to significantly reduce its

- growth rate
- survival
- fecundity.

This information is being used in the ongoing search for an effective proteinase inhibitor. Highly active inhibitors of proteinases, insensitive to potato-derived inhibitors, have been identified in vitro. They will be tested for efficacy in vivo.

Insect pest control and pesticide persistence Bioassays compared relative persistence of nine control agents applied to potato foliage for control of Colorado potato beetle (CPB). Results: fipronil was most persistent, followed by

- cypermethrin
- imidacloprid
- cryolite
- spinosyn
- chlorfenapyr
- cyromazine.

These data will assist resistance management programs to maximize effective lifetime of CPB control agents.

We have developed a leaf dip bioassay, based on a discriminating dose of Admire, that distinguishes susceptible and resistant strains of CPB. This laboratory test will be used to develop a rapid field bioassay for detecting resistance.

Efficacy data was collected to support registration of imidacloprid, an insecticide with a new mode of action for control of tobacco aphid, *Myzus nicotianae*. Registration and application of imidacloprid are critical components of an insecticide resistance management program for the most serious insect pest of Canadian tobacco.

Efficacy and crop residue data were generated to permit "User Requested Minor Use Label Expansion" of current labels for

- cypermethrin, to include cutworm control on stevia
- permethrin, to include cutworm control on American ginseng.

Effective insect control will enhance profitability and competitiveness of these promising Canadian crops.

A rearing method has been developed for *Stethorus punctillum* (Coleoptera: Coccinellidae), a native predatory beetle of spider and red mites. Releases have been made into Ontario orchards to determine the feasibility of an integrated pest management strategy using this species. Testing of the beetle as an early-season control of spider mites in greenhouses will be conducted in cooperation with the Pacific Agri-Food Research Centre.

Plant disease control Several *Verticillium* isolates not pathogenic on tomato act as cross-protecting biological control agents against verticillium wilt of tomato. We have developed a model system using these isolates to optimize conditions for cross-protection of tomato transplants.

A DNA fingerprint probe has been developed for differentiating race 2 isolates of *V. dahliae*. Using this probe, preliminary experiments indicate that

- the race 2 population in processing-tomato fields in Ontario is not genetically homogeneous
- a particular group of *V. dahliae* isolates that causes disease on potato but not tomato has the potential to become pathogenic on tomato.

This technology will accelerate the selection of race 2 isolates from *V. dahliae* for breeding *Verticillium*-tolerant or race-2-resistant cultivars.

Antagonistic bacteria have been isolated from tomato rhizospheres. These *Streptomyces* spp. are being formulated for suppressing root-rotting and damping-off fungi that limit greenhouse production of tomato transplants. The diseases that may be suppressed in 10- to 14-day-old tomato seedlings by 90 % when added to the standard peat-based potting mixes are

- *Rhizoctonia*
- *Pythium*
- *Fusarium*
- *Thielaviopsis*.

The genetic region associated with plant growth promotion by a nonfluorescent *Pseudomonas* sp. was identified using transposon mutagenesis and complementation. The smallest DNA segment associated with growth promotion was determined by shotgun cloning. This segment will be sequenced and used to determine how growth promotion functions in such rhizosphere bacteria.

The oomycete pathogen *Phytophthora sojae* causes root rot of soybean. A collaborative project is ongoing with the Greenhouse and Processing Crops Research Centre and the Noble Foundation in Oklahoma to study genes that determine pathogen virulence and host resistance. Genetic maps have been constructed around the *Avr1a* region in *P. sojae* and the *Rps1k* locus in soybean. These maps are based on randomly amplified polymorphic DNA and amplified fragment length polymorphism markers. The next step is to isolate bacterial artificial chromosome clones using the markers to generate physical maps of the regions.

Organic amendments to soil Manures from various sources and biosolids derived from meat and bone meal, soymeal, pulp, and paper were tested for their impact on populations of plant pathogenic bacteria, fungi, and nematodes. Results:

- Laboratory tests employing small quantities of field soil mixed with various rates of amendments accurately predict the efficacy of treatments for controlling potato diseases caused by *Verticillium dahliae* and *Streptomyces scabies*.
- Materials having high nitrogen content were highly effective in controlling a wide spectrum of soilborne plant pathogens, but the effect was soil specific.

The mechanism of action is at least partially explained by the generation of volatile toxic gases derived from the decomposition of the amendments. Unlike chemical fumigants, which cause a decrease in the populations of all soil microorganisms, biofumigation is selective and significantly enhances soil microbial populations. Under microplot tests, a single application of high-nitrogen-containing amendments protected plants over 3 years and resulted in large increases in yield and improvement in tuber quality. Commercial field testing is now in progress for potatoes.

An agar medium has been developed that allows for specific isolation of Actinomycetes and Streptomyces bacteria from soil. The medium was used to quantitatively determine the populations of plant pathogenic *Streptomyces* spp. in scab lesions on potatoes and in soil.

Herbicide-induced disease resistance Tomato seedlings grown in the presence of low levels of certain dinitroaniline herbicides show

- enhanced resistance to *Fusarium oxysporum* f. sp. *lycopersici*
- dose-related increases in total free amino acids.

This effect did not persist long after removal of the plant from the chemical's presence. However, it may provide sufficient protection to enable plants to survive the critical period immediately after transplantation to the field. The levels of free amino acids in the roots of tomato seedlings treated with such herbicides and possibly other inducers could possibly be used to indicate the extent of resistance induction.

Stevia A basic production system for stevia has been established, including the design and construction of harvesting and leaf threshing machines. New genotypes conforming to the optimum product specifications and process needs were identified, and stable populations developed. Pilot production demonstrates that 3000 kg/ha at 18% glycosides is attainable. Means of controlling septoria disease were identified. *Septoria steviae* was recovered from stevia plants for the first time in North America and shown to be pathogenic.

Ginseng Composts were shown to be effective in reducing

- populations of the soilborne fungal pathogens *Phytophthora cactorum* and *Cylindrocarpon destructans*
- severity of root disease of ginseng (*Panax quinquefolium*).

We have developed a liquid chromatography (HPLC) method for determining ginsenosides in ginseng. Ginseng root weight and levels of the ginsenosides Rb₁, mRb₁, Re, and Ro increased with age of the root. Ginseng harvested after only 3 years contained lower amounts of ginsenosides than ginseng harvested after 4 years.

We measured the influence in ginseng root of drying temperature on

- color
- major carbohydrates
- ginsenosides.

Higher drying temperatures darkened root color and reduced concentrations of sucrose, the malonyl-ginsenosides mRb₁, mRb₂, mRc, and mRd, and the neutral ginsenosides Re and Ro. Ginsenosides Rb₁, Rc, Rd, and Rg₁ were not affected by drying temperature. The optimal drying temperature range for American ginseng is 32°–38°C.

Dieback of the herb evening primrose was increased by interactions between the plant pathogens

- *Septoria oenotherae*
- *Botrytis cinerea*.

Flue-cured tobacco Isolates of *Thanatephorus cucumeris* belonging to *Rhizoctonia solani* anastomosis group 3 were

- widespread in southwestern Ontario
- able to reproduce symptoms of target spot on *Nicotiana tabacum*.

A modified screening procedure was developed to identify *N. tabacum* lines with increased levels of resistance to black root rot. Addition of specific amino acid and carbohydrate sources to spore suspensions increased

- production of antifungal compounds by the antagonistic fungus *Epicoccum niger*
- inhibition of the plant pathogen *Sclerotinia sclerotiorum* by *E. niger*.

Soil porosity and soil biological activity Tension infiltrometer field data demonstrated that forested soils had a greater capacity for air and water storage and water transmission than adjacent conventional and no-tillage sites. The soil matrix under no-till was both less permeable and less well-aerated than adjacent conventionally tilled soils.

Pesticides and biological activity in soils Soil chemical properties are changed by earthworm activity. Worms increase the adsorption of the herbicide atrazine and reduce its mobility in soil. Joint research with INRA and Ciba-Geigy shows that manuring increases the number and activity of atrazine-degrading bacteria in soil.

Enhanced degradative activity toward disulfoton sulfoxide/sulfone was observed in soils 3 years after the last application of disulfoton. This result caused a significant reduction in the levels of disulfoton-derived toxicants in potato foliage grown in the previously treated soils, compared with the levels observed in potatoes grown in soil receiving an initial application of the pesticide. Insecticide application history needs to be considered in developing pest control programs.

Tillage practices and biological activity in agricultural soils Assays of soil enzymes show that dehydrogenase and phosphatase activities are significantly higher under no-till than conventional tillage practices. After 7 years of conventional and organic-farming practices, nitrification is significantly greater in organically farmed than in conventionally farmed vegetable plots. Higher lipid content and respiration rate were found in soils subjected to organic methods of growing five vegetable crops than in soils managed using conventional methods. These results suggest that the numbers and activity of the soil microflora may be higher in the organically managed soil.

A bilateral international research program has been established with the Centre for Agro-Landscape Research, using shared research sites from Ontario and Germany. The impact of tillage practices on several soil quality characteristics will be measured.

Nitrogen management on coarse-textured soils Overseeding rye into corn reduced nitrate leaching under conventional and no-till practices. Nitrogen released by rye residue decomposition improved overall nitrogen availability for the crop in conventional till. Grain yields increased by 390 kg/ha with the rye cover (3-year average) when fertilizer N-rates exceeded 125 kg N/ha.

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Mandate

The Greenhouse and Processing Crops Research Centre develops methods for improving the productivity of

- greenhouse vegetable crops
- field vegetable crops
- oilseed and protein seed crops.

In addition, it conducts research in Ontario soils to

- develop best management practices
- improve quality
- characterize physical and chemical attributes.

The Canadian Clonal Genebank is also located at the centre.

Resources

The centre employs 88 full-time equivalents including 20 scientists and manages a budget of \$7.5 million. The centre houses the Canadian Clonal Genebank. Field operations occur at

- the main centre and Ridge field site, covering 131 and 21 ha, respectively, of representative sandy loam soils
- Hon. E.F. Whelan field site in Essex County, covering 67 ha of Brookston clay soil.

The centre shares office and laboratory space with extension specialists of Ontario's Ministry of Agriculture and Food and Rural Affairs. The Ontario Land Resource Unit located in Guelph also reports to the centre.

Achievements

- *Staff awards and honors*
- *Economic injury levels*
- *Survival of biocontrol agents*
- *Dry bean breeding*
- *Field crop breeding and variety development*
- *Soybean cyst nematode*
- *Crop protection*
- *Greenhouse vegetables*
- *National Greenhouse Vegetable Research Network*
- *Newly identified disease*
- *Greenhouse control*
- *Tomato thin pulp and rheological properties*
- *Technique for improving crop growth*
- *Trifluralin, metalochlor, and metribuzin*
- *Soil and water*
- *Insect trapping*
- *Colorado potato beetle thresholds in tomatoes*
- *Verticillium wilt*
- *Weed management*
- *Liquid manure management*
- *Agricultural profile of the Great Lakes basin*
- *Environmental indicators*
- *Canadian Clonal Genebank*

Staff awards and honors A. Liptay, J.L. Barron, T.J. Jewett, and I. van Wesenbeeck received the Outstanding Cross Commodity Publication Award from the American Society for Horticultural Science.

Dr. J.D. Gaynor was the recipient of a 3-month honorary visiting professor scholarship to the Research Institute for Bioresources, Okayama University, Kurashiki, Japan. While there, Dr. Gaynor

- conducted research on photodegradation of herbicides in water
- presented lectures on research being done at the centre and specifically on the role of clay and organic matter on herbicide interactions

Drs. K.B. MacDonald, D. Reynolds, and G.J. Wall received Agcellence Awards in recognition of their contributions to the outstanding publication entitled “The Health of Our Soils - Towards Sustainable Agriculture in Canada.”

Economic injury levels In greenhouse studies, levels for fruit damage and yield loss caused by immature and adult western flower thrips on greenhouse sweet pepper were determined. Information will be used to improve timing and determine cost effectiveness of control measures.

Survival of biocontrol agents A mathematical model was constructed to predict survival rates for thrips biological control agent, *Amblyseius cucumeris*, at various combinations of greenhouse temperature and vapor pressure deficit. Information will be used to improve greenhouse microclimate conditions to optimize control effectiveness.

Dry bean breeding Three colored bean cultivars were registered and breeder seed released:

- AC Calmont, a dark red kidney bean for improved yield and processing quality

- AC ELK, a light red kidney bean for improved yield and early maturity
- AC Ole pinto bean, for improved yield and medium maturity for export market.

Two new pulse crop cultivars were released:

- AC Harosprout mungbean for bean sprout, to replace present imports
- AC Gemco, an azuki (small red) bean with improved yield and large seed for export to Pacific Rim.

Field crop breeding and variety development A white mold nursery was established for identification of resistance to *Sclerotinia sclerotiorum*. Some 214 soybean crosses were made for

- disease and soybean cyst nematode resistance
- quality enhancement
- yield improvement.

Preliminary calibration of near infra-red instrumentation for analysis of sucrose and stachyose in soybeans was performed. Interaction between soybean and weed species under water stress was determined and two high-protein tofu-type soybean varieties were released.

Soybean cyst nematode Evaluation of varieties from public and private breeding programs resulted in support for registration of three new varieties with resistance to soybean cyst nematode. The best nonhost crops to reduce soybean cyst nematode (SCN) populations were:

- sorghum
- sudan grass
- corn.

These crops reduce SCN populations 30–60% annually and should be used in rotation with soybean when economically feasible.

Crop protection Careful removal of moldy bean alleviates mycotoxin contamination.

Greenhouse vegetables Stem and peduncle canker of greenhouse pepper incited by *Erwinia carotovora* pv. *Carotovora* was identified for first time in Ontario. The organism is known to cause extensive losses.

National Greenhouse Vegetable Research Network An inaugural meeting was held in April 1996 to review research progress and identify research priorities. Five issues in crop production and three issues in crop protection were affirmed as encouraging areas for on-going cooperation between AAFC centres in Ontario and British Columbia.

Newly identified disease Powdery mildew (*Erysiphe* sp.) found on greenhouse tomatoes was also found to cause extensive losses in processing field tomatoes. Resistance has been observed in several wild species of tomato.

Greenhouse control Data logging systems were developed to

- monitor microclimate in greenhouse cucumber crop canopies
- detect climate conditions that could lead to disease and insect outbreaks
- transfer climate data from greenhouse climate-control computers to decision-support computers
- allow the control of greenhouse climate to be integrated with the Harrow greenhouse crop manager.

Tomato thin pulp and rheological properties Composition of tomato thin pulp provides a quantitative method of measuring how different biochemical tomato fruit components interact and affect tomato paste product characteristics.

Technique for improving crop growth Optical flow instrumentation was used to measure very minute changes in corn seedling growth noninvasively and nondestructively. The technique will be of use in improving crop growth by measuring responses of individual plants to changes in different production inputs.

Trifluralin, metalochlor, and metribuzin As a result of a “User Requested Minor Use Registration,” trifluralin, metalochlor, and metribuzin in a three-way tank mix is now available for use by growers of processing tomatoes. Companies marketing these products are modifying labels to accommodate registration as required by the centre’s protocol. The mixture allows for a reduction in application rate of each of the materials and widens the spectrum of weeds to be controlled.

Soil and water A controlled drainage - subirrigation system was established on a sandy loam site to study effect on processing tomato production and tile drainage water quality. Results:

- reduction of nitrate loss
- increase of marketable tomato yields
- improvement in soil structure by combination of no-tillage and controlled drainage system
- prevention of excessive nitrate leaching through tile drainage water.

Significant advances were made in development and application of two methods for determining hydraulic properties of soils.

In a greenhouse study using undisturbed soil cores, water table control was found to affect corn growth and N losses through denitrification and leaching. Although controlled drainage and subirrigation reduced flow weighted mean NO_3 -concentration of tile drainage water, technological advancement was obtained for fine texture soils. A new method to measure nitric oxide in the presence of acetylene was developed.

Insect trapping In collaboration with the Pacific Agri-Food Research Centre, an insect trap was developed for trapping Colorado potato beetles in commercial potato and tomato fields. The trap is capable of capturing walking beetles as they emerge from overwintering, thus reducing the number of insect sprays. The product is patent pending and will soon be available for commercialization.

Colorado potato beetle thresholds in tomatoes Damage thresholds established for Colorado potato beetle on processing tomatoes at various plant ages were determined. Results:

- the damage thresholds are much higher for older plants
- mid and late season insecticidal control are not required on processing tomatoes.

Verticillium wilt A new micro-injection method was developed for rapid and accurate screening. The method requires no transplanting and uprooting of plants for diagnosis.

Weed management Data were provided for support of approval for registration of clorimuron for weed control in soybeans in Canada. A software package called Ontario Herb was developed to assist soybean and corn growers in postemergence weed control decisions using economic threshold approach. Discovered were paraquat-resistant biotypes of two weed species:

- Canada fleabane
- poor-man’s peppergrass.

Liquid manure management Studies were done on methods of liquid manure application in no-till corn production systems. The movement of contaminants to field tile water is reduced by modifying the application equipment and by adjusting application methods to account for soil texture.

Research was conducted in cooperation with private industry on precision nutrient management using liquid manure. Current technology results in highly variable application rates. The uniformity is improved by equipment modification

- to improve the splash plate design
- to monitor and control the flow rates.

Agricultural profile of the Great Lakes basin Agricultural activities in Canada and the United States have been characterized to show

- intensification and specialization of agriculture from 1981 to 1991
- areas of concentrated livestock enterprises where waste management problems are probable
- areas of increasing pressure on agriculture from increases in rural and urban populations.

Environmental indicators Risks of soil erosion by water (an indicator of soil degradation) and risk of water contamination in Ontario have been determined for 1981 and 1991 using Census of Agriculture. These indicators show

- trends in risk of soil degradation and water contamination as a result of changes in agricultural practices
- areas that require additional efforts to reduce the risk to acceptable levels.

Canadian Clonal Genebank The collection was successfully moved from the Smithfield Research Farm to Harrow. All tree fruit stock was repropagated onto new rootstock and small fruit accessions were maintained in containers during the relocation. One hundred and thirteen requests for germplasm including 1686 accessions and nearly 11 000 propagation units were filled during the past year.

Research Publications

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* Reports to Cereal Research Centre (Winnipeg)

** Reports to Saskatoon Research Centre

Mandate

The Eastern Cereal and Oilseed Research Centre (ECORC) develops new varieties and crop protection and management systems for the sustainable production in eastern Canada of

- corn
- cereals (wheat, barley, oats)
- soybeans.

ECORC is also responsible for land and biological resource evaluations and pest diagnostics for all of Canada.

Resources

The Eastern Cereal and Oilseed Research Centre (ECORC) was created in April 1996 by amalgamating programs from the former Centre for Land and Biological Resources Research and the Plant Research Centre. It is located in Ottawa on the Central Experimental Farm (CEF).

The centre houses the following internationally recognized reference collections:

- Canadian National Collection (CNC) of Insects, Mites, Arachnids, and Nematodes
- Canadian Collection of Fungal Cultures, also called CCFC
- National Mycological Herbarium, also called DAOM
- Vascular Plant Herbarium, also called DAO.

These internationally recognized acronyms identify where a specimen is maintained and can be accessed

D=Department; A=Agriculture; O=Ottawa; M=Mycology.

Also located at the centre are

- National Identification Service, dealing with specimens of insects, mites, spiders, nematodes, vascular plants, and fungi
- National Soil Database
- Canadian Soil Information System.

The centre is responsible for operations on the 500-ha CEF, including maintaining

- the Arboretum
- the Ornamental Gardens
- growth facilities
- experimental fields for CEF establishments.

In 1996-97 ECORC began with a research staff of 458 full-time equivalents (FTE), including 145 in the professional categories, and managed a research budget of \$32.7 million. Through redeployment and reorganization of programs over the course of the year, the centre's staff has been adjusted to 315 FTEs and approximately 70 professionals.

Achievements

- *Staff awards and honors*
- *Molecular technologies for plant insect resistance*
- *Corn: inbred release, fumonisin mycotoxin*
- *Quantifying fusarium infection*
- *Corn: fusarium ear mold, tissue regeneration*
- *Wheat: soft white winter variety*
- *Wheat: mycotoxin detection*
- *Wheat: fusarium head blight epidemic*
- *Oats: variety development*
- *Oat genome research*
- *Barley breeding*
- *Quality traits of Canadian barley varieties*
- *Microspore embryogenesis in canola*
- *Patents filed*
- *Soybean: varieties released, genetic gain*
- *Soybean transformation and molecular technologies*
- *Soybean: quality for natto production*
- *Soybean: association of pubescence color with maturity and yield*
- *Micrometeorological techniques to gage agriculture - environment interactions*
- *Agrochemicals*
- *Soil organic matter levels*
- *Crop management aids*
- *Biodiversity in relation to agriculture*
- *Fusarium identification key*
- *The mushroom industry*
- *Wild relatives and crop species*
- *Germplasm improvement in forages*
- *Germplasm improvement in Brassica*
- *Identification aids for chalkbrood of leafcutting bees*
- *Beetle identification improved*
- *Information system on plant pests*
- *Canadian Collection of Fungal Cultures (CCFC)*
- *Taxonomic Information Systems (TIS)*
- *Soil conservation and sustainable land management*
- *Soil and water quality*
- *Crop and weather data and modeling*
- *Geographical Information Systems (GIS)*
- *National Soils Database (NSDB)*

Staff awards and honors Dr. Lubomir Masner was awarded an honorary research associate of the American Museum of Natural History, New York, in recognition of his outstanding accomplishments in the study of parasitic wasps. Many of these insects parasitize eggs of a variety of pests of economic importance to agriculture.

Molecular technologies for plant insect resistance The expression of insect-resistance genes that are wound-inducible in plants was achieved in several species, including

- canola
- tomatoes

- tobacco
- green peppers.

These genes encode protease inhibitors that exhibit insecticidal activity in several insect bioassays. The expression of protease inhibitors on the surface of filamentous phage

- has allowed us to design libraries of mutant inhibitors
- will permit the selection of genes with elevated specificities and efficacies.

Corn: inbred release, fumonisin mycotoxin The corn program is releasing 10 inbreds this year, CO412-CO421.

- CO412 is the second inbred with both *LFy1* and *rd1* genes.
- CO417, CO419, and CO421 are three very early inbreds that adapt to a short season.
- CO418 was developed for low-temperature tolerance from a composite of the best European early hybrids.

Fumonisin B, a mycotoxin produced on corn by *Fusarium moniliforme*, was purified from cultures of the fungus. A large amount of purified toxin was required by Health Canada and for a cooperative toxicological study with animal research scientists at CEF. Fumonisin is considered to be a cancer-causing mycotoxin.

Quantifying fusarium infection A molecular procedure to quantify fungal biomass in fusarium infections was established. It evaluates the amount of fungal DNA present in infected grain samples using DNA probes specific to either

- *F. graminearum*
- *F. moniliforme* or
- any *Fusarium* species.

This procedure will help

- to evaluate breeding material for resistance to fungal growth
- to study the competition between *Fusarium* species during infection.

Corn: fusarium ear mold, tissue regeneration A joint corn field trial with the United States Department of Agriculture involving transgenic *Fusarium graminearum* strains was conducted in Ottawa and Illinois. The study was partially funded by the Ontario Corn Producers Association. The genetically modified fungal strains lacked the ability to produce the trichothecene mycotoxin deoxynivalenol (DON). The trials were designed to determine the role of DON as a virulence factor in the infection of corn by *F. graminearum*. Corn ears infected with the transgenic non-DON-producing strain had

- a much lower disease severity index
- a higher yield of grain that was free from DON.

Lines of corn tissue cultures that exhibit an excellent ability to regenerate into plants have been developed from crosses involving early-maturing ECORC inbreds. This characteristic greatly increases the efficiency of corn transformation. Transformed plants that contain the oxalate oxidase gene have been recovered and will be tested for increased resistance to fungal diseases.

Wheat: soft white winter variety A new soft wheat cultivar, AC Cartier, was registered in 1996. This cultivar has expressed a high degree of winter survival and is well adapted to all areas of soft white winter wheat production. It has excellent yield and good quality characteristics.

Wheat: mycotoxin detection A monoclonal antibody-based immunological test was improved to allow rapid measurement of the concentration of the mycotoxin deoxynivalenol (DON) in single wheat kernels damaged by fusarium head blight disease. The diseased kernels, known as fusarium-damaged kernels or tombstone kernels in grade standards, contained several hundred parts per million of the mycotoxin, compared with less than five parts in healthy-looking kernels.

Wheat, fusarium head blight epidemic In 1996 the winter wheat crop in Ontario was devastated by an epidemic of fusarium head blight. The result:

- severely reduced yields
- poor test weight
- high levels of seed infection
- contamination with the mycotoxin deoxynivalenol.

In cooperation with the Ontario Ministry of Agriculture and Food and the Ontario Wheat Producers' Marketing Board, and with support from other industry organizations, ECORC participated in a province-wide survey of wheat fields

- to determine the incidence and severity of the disease in the field
- to obtain samples of grain from the fields before and after harvest.

Studies are under way

- to determine the levels of seed infection and mycotoxin contamination of the grain
- to identify the fungi associated with the outbreak
- to evaluate the effectiveness of growers' efforts to improve the quality of harvested grain by adjustments to the air flow of their combines.

Oats: variety development The oat program has had a very productive year, having

- re-registered the high protein oat Hinoat, which was requested by Canamino Inc. to make cosmetic products
- registered the rust-resistant covered-seeded oat AC Francis (OA 961-1), required by the milling industry in Ontario
- registered the naked-seeded oat AC Fregeau (NO 857-28) as a feed and food grain, which will be grown mainly in Quebec
- obtained restricted registration for the hull-less oat NO115-1, which has been requested by UFL Foods for the development of a new product to replace rice
- obtained restricted registration for the covered oat OA952-3, which was requested by Quaker Oats for evaluation as a milling oat
- obtained support to register the high-yielding agronomically superior hull-less oat NO61-1 (AC Ernie)
- identified high-yielding adapted lines that carry the crown rust resistance genes *Pc50*, *Pc62*, and *Pc68*.

Oat genome research A genome map based on restriction fragment length polymorphism in hexaploid oat has been published. This map, developed in a collaborative effort funded by the Quaker Oat Company, is providing the foundation for other genetic studies in oat.

A manuscript defining the genomic positions of stem rust resistance genes *Pg9* and *Pg13* has been published.

Mapping of three additional crown rust genes is nearing completion. By tagging the location of these genes with molecular markers, we now have the opportunity to pyramid multiple rust-genes to achieve a more durable form of resistance.

The oat RFLP map is providing opportunities to compare the oat genome with related grass species such as

- rice
- wheat
- barley.

This research also results in a wider selection of molecular markers for fine-mapping of specific regions of the genome.

Barley breeding A six-row barley variety AC Alma (AB151) was registered in 1996. AC Alma is superior to other varieties across Eastern Canada in

- grain yield

- lodging resistance.

A two-row barley line, DB202, was supported for registration in 1996 by the

- Ontario Cereal Crops Committee
- Atlantic Advisory Committee on Cereals and Oilseeds.

DB202 was developed by the doubled-haploid method. It yields well and has good resistance to many diseases.

Quality traits of Canadian barley varieties All 76 barley varieties registered in Canada were studied for

- grain yield
- grain composition
- straw composition
- agronomic traits
- kernel color.

In general, two-row barleys produced less grain and more straw than six-row varieties. Compared with six-row varieties, they had

- higher test weight
- higher 1000-seed weight
- more resistance to lodging
- more starch
- less fiber
- less beta-glucan.

Eastern two-row varieties were superior to western two-row varieties in

- yield
- test weight
- seed weight
- protein content
- lodging resistance.

Hull-less barleys contained more protein, more starch, and less fiber than covered barleys. Some eastern varieties yielded well in both eastern and western Canada.

Microspore embryogenesis in canola Chemical-inducing agents have been identified that trigger embryogenesis from microspores of *Brassica napus* cv. Topas. One such agent, colchicine, was particularly useful, serving as

- an inducing agent for embryogenesis
- a chromosome doubling agent.

Over 90% of plants regenerated from colchicine-induced microspores were doubled haploids. A high seed yield from each of these plants allows direct field testing, unlike traditional doubling at the plant level. Chimeras produced from the labor-intensive traditional method require an additional cycle of plant growth to produce sufficient seed for field testing.

Patents filed The following patents were filed:

- A *Brassica* sp. gene promoter highly expressed during stigma development. Robert, L.S., Gerster, J.L., and Simmonds, J. United States Application Number: 08/617,101. Filing date March 18, 1996
- A *Brassica* sp. gene promoter highly expressed during tapetum development. Robert, L.S. and Hong, H.P. United States Application Number: 08/595,937. Filing date: February 6, 1996
- Anti-sense RNA for *CAB* transcript to reduce chlorophyll content in plants. United States Application Number: 08/570,929. Johnson-Flanagan, A.M., Singh, J., Robert, L.S., and Politeski Morissette, J.C. Filing date:

December 12, 1995

- A *Brassica* sp. polygalacturonase gene promoter. United States Application Number: 08/577,463. Robert, L.S., Gerster, J.L., and Hong, H.P. Filing date: December 21, 1995
- Cold-inducible promoter winter *Brassica napus*. United States Application Number: 08/421,044. Singh, J., White, T., and Jiang, C.
- A seed-coat-specific cryptic promoter in tobacco. United States Patent Application Number: 08/441,597. Miki, B., Fobert, P., et al.
- Induction of embryogenesis using cytoskeleton inhibitors or protein synthesis inhibitors. United States Patent Application Number: 02/145,833. Simmonds, D.H., Newcomb, W.

Soybean: varieties released, genetic gain The following cultivars were released:

- AC Hercule, a high protein variety for on-farm feeding
- AC Cormoran, a full-season 2700 Crop Heat Unit oilseed variety with a unique combination of maturity genes that result in a new phenotype called tall determinate, which has the advantage of having the lowest pods higher off the soil surface
- Alpha, an early-maturing oilseed type
- Medallion, an early - medium maturity oilseed type
- Achiever, a full-season oilseed type with high yield potential
- 9063, a high-yielding, full-season oilseed type
- AC Colombe, an early-maturity small-seeded type for export to the natto market.

Soybean cultivars released over the past 58 years were grown in tests in Ontario and Quebec to evaluate genetic gain attributed to plant breeding. Since 1976, yields have been increasing about 0.7% per year. It appears that the rate of progress may be increasing.

Soybean transformation and molecular technologies Improvements have been made to transformation protocols for short-season varieties. An ECORC soybean line has been transformed with an oxalate oxidase gene, which may confer a degree of resistance to sclerotinia (white mold).

Seed coat cDNA libraries have been constructed and putative seed-coat-specific clones have been identified in a collaborative project with the Pest Management Research Centre, London.

Soybean: quality for natto production A study of genotype × environment effects on natto soybean quality traits revealed that genotype is more important than genotype × environment effects when quality traits are examined. This finding indicates that

- broadly adapted natto cultivars are being developed for eastern Canada
- the testing region does not need to be subdivided.

Soybean: association of pubescence color with maturity and yield Sister lines of soybeans were developed to examine the relationship between pubescence color and climate. There was a positive correlation between soybeans with tawny pubescence color and cool-season adaptability. Areas receiving less than 2600 Crop Heat Units should grow soybeans with tawny pubescence. Early maturity was found to be associated with brown-pubescence color. Brown pubescent lines matured on average 8 days earlier than gray-pubescent lines.

Micrometeorological techniques to gage agriculture - environment interactions CO₂ flux measurements were successfully used to estimate the impact of soil management on soil organic C. For example, the loss of carbon by soil respiration in small-grain cropping systems was more important early in the season under conventional tillage, mainly because the soil temperature was warmer than under no-tillage.

A software package that controls a tower-based flux-measuring system was developed, based on the eddy covariance and the relaxed eddy accumulation technique. This system was successful in measuring

- crop photosynthesis
- evapotranspiration
- herbicide volatilization
- fluxes of ammonia, ozone, and methane.

Agrochemicals Several bound pesticide residues in soil and food commodities were characterized using new methodology. This information supported pesticide-regulatory decisions related to environmental quality and food safety.

Engineered strains of *Rhodococcus* species were found to either extensively degrade or biotransform a number of pesticides belonging to different classes, for example

- phenylcarbamates
- sulfonyleureas
- 2,4-D
- methiocarbamates oximes and nitriles.

These results indicate that multi-pesticide degradation capacities could be genetically engineered into selected soil bacteria.

The herbicide atrazine, used in corn production, is mobile in soil and is frequently detected in surface and groundwater. Typically there is a lag period before atrazine is degraded. This lag period was significantly shorter, however, in soils that received manure amendments. This result was due to the larger number of atrazine-degrading microorganisms that are stimulated by the increased nutrient availability in the manured soils.

Soil organic matter levels Comparison of soils under cropland and adjacent forests indicated cropland had

- 34% less C
 - 19% less N
 - 24% more P
 - lower losses than the 50 - 70% found in earlier studies, conducted mostly on western Canadian soils.
- This finding suggests losses in soil organic matter attributed to agricultural production are dependent on soil type and factors such as erosion.

The mean store of organic C and N was determined to a depth of 60 cm for a range of different soil types in eastern Canada under various agricultural management systems. Results indicated that these soils have a relatively high potential for increased organic matter storage.

The ability of soils in Canada to act as a sink for atmospheric carbon was evaluated. Adopting the following options could sequester about 50 - 75% of the total agricultural emissions of CO₂ in Canada for the next 30 years:

- reduced summerfallow area
- increased use of forage crops
- improved erosion control
- shifts from conventional to minimal and no-till
- more intensive use of fertilizers.

Different tillage systems produced no significant differences in total soil organic matter, although the distribution of organic matter varied with depth. Reduced tillage systems would not result in increased soil organic matter levels within 5 - 10 years after the initiation of the tillage system.

Crop management aids A detailed data base of background levels of a large number of minor and trace elements in an important Ontario agricultural soil was established for

- development of soil - crop - element relationships
- determining the influence of long-term agricultural practices.

On-farm mycorrhizal inoculum production technology provided a seed-applied inoculum capable of improving corn yields under low, moderate, and high rates of inorganic nitrogen fertilization for

- continuous corn
- corn - soybean rotations.

Management of mycorrhiza should allow corn yields to be maintained under reduced nitrogen inputs.

Increased rooting depth was associated with increased tillage and decreased moisture in the surface soil. Root mass distribution, however, is similar under all conventional and conservation tillage practices.

Reduced tillage slowed the rate of emergence and reduced corn establishment because of cooler soil temperatures. Prediction of emergence may be improved by a new temperature response function for the emergence period.

Biodiversity in relation to agriculture An analysis of the native plant biodiversity in the most populated and agriculturally important region of Eastern Canada was completed and is provided on the Internet (<http://www.cciw.ca/eman-temp/reports/publications/Mixedwood/>).

A new native grass useful as an indicator species for ecologically sensitive maritime areas was discovered in northern Quebec.

Fusarium identification key To use the key, scientists input their microscopic observations onto an illustrated data sheet. The information is then compared with a database including 40 common species, and the user is presented with a list of possible identifications. This user-friendly, bilingual illustrated key to species of the most important genus of plant pathogenic fungi in Canada was released for use on the World Wide Web in January 1996. The key can be accessed at the following URL: <http://res.agr.ca/brd/fusarium/>.

The mushroom industry Ontario mushroom growers have experienced crop losses as high as 75% from a green mold disease caused by aggressive strains of *Trichoderma harzianum*. In collaboration with Brock University and the Canadian Mushroom Growers Association, a rapid, economical identification technique was developed to distinguish the pathogenic strains from morphologically similar *Trichoderma* strains. The method is semiautomated. It is based on carbon compound assimilation profiles on a 96-well microplate.

Wild relatives and crop species The following advances were made:

- information completed to aid in the preservation and management of wild forage grasses in eastern Canada, especially brome grasses and wheat grass relatives
- information published to prevent confusion between poisonous and edible “star anise” species, which are important as herbs and ornamentals
- bioclimatic patterns found to be valuable for selection of wild strawberries for breeding and germplasm protection
- a molecular analysis of the national strawberry collection done, as a means of reducing collection size and maintenance cost with minimum loss of genetic variation
- an annotated list of rare Canadian crop germplasm published
- a geographic information system developed to prioritize germplasm for protection
- descriptions published of pharmacological crops with potential for increased economic value in Canada
- a scanning electron microscopy study conducted of insect-repellent hairs in wild potato species that have potential for breeding potatoes with reduced need for pesticides.

Germplasm improvement in forages The following results were achieved:

- germplasm of wild populations of forage grasses discovered and collected in eastern Canada, including brome grass and slender wheat grass -- all have natural tolerance to cold, drought, and salinity
- agronomic information collected for several lines of wild forage brome grasses -- useful for ongoing breeding programs
- studies completed on artificial hybrids between smooth and meadow brome grasses -- they provided collaborators in forage-breeding programs with information essential to improving forthcoming commercial lines
- a review published of characteristics that make alfalfa resistant to insects
- a review published analyzing the different kinds of bird's-foot trefoil useful for Canadian cultivars.

Germplasm improvement in Brassica The germplasm base for *Brassica* was improved enormously through research emphasizing genetic relatedness and genetic diversity at the molecular level. Several genera previously assigned to separate distant subtribes were found to have close genetic relatedness to the *Brassica* crops.

Identification aids for chalkbrood of leafcutting bees Leafcutting bees pollinate alfalfa seed fields. Chalkbrood is a fungal disease of leafcutting bee larvae caused by species of *Ascosphaera*, for which no cure is currently known. To aid scientists attempting to solve the problem, species concepts for the pathogens have been clarified, resulting in the description of the new species from Alberta, *A. acerosa*. A total of 21 species of *Ascosphaera* are now known to be involved in chalkbrood, and a key has now been published to facilitate their identification.

Beetle identification improved Identification keys were developed for spurge flea beetles introduced in Canada for the biocontrol of spurge. Spurge is an invasive weed toxic to livestock and is a very serious agricultural problem in the Canadian prairies.

Collaborative work with the Lethbridge Research Centre led to the clarification of the taxonomic status of two sibling *Altica* flea beetles that are currently being tested for the biocontrol of Canada thistle. Canada thistle is a weed that is highly detrimental to the quality of pastures in the western provinces. Preliminary results indicate that the Chinese flea beetle stock might be better adapted to the Canadian conditions than the European one.

The first part of a monograph on *Altica* flea beetles was published, including the first illustrated identification keys to both sexes of these insects. This large group of flea beetles comprises several pest species but its taxonomy is still largely confused.

Description of the immature stages of a species of clytrine beetle and a detailed account of its biology was completed. Clytrine beetles are occasionally responsible for severe infestations of various cultivated plants.

Carabid beetles prey on other invertebrates and act as natural control agents of arthropod pests of agriculture and forestry, including

- gypsy moth larvae
- cankerworms
- cutworms.

The species identities of two tribes were resolved in order that the North American species could be identified from foreign species that might be introduced for improved biological control.

A taxonomic review was published clarifying the identities of the Nearctic species of *Ostoma* beetles (Trogossitidae). These beetles are biologically diverse:

- some feed on fungi
- some are predaceous
- some are pests in stored grain.

Information system on plant pests An information system on the scale insects of the world was developed, in collaboration with specialists in the United States and Israel. These serious pests of plants

- transmit diseases
- suck sap
- cover tissue with large quantities of honeydew.

The interactive information system is accessible on the Internet at <http://www.sel.barc.usda.gov@>.

An identification key to the species of Pyralidae of British Columbia was developed, in collaboration with British Columbia Forestry and the University of Victoria. Separation of the 10 species present in British Columbia is pivotal to orchard pest management efforts. These moths are serious seed pests of seed orchards.

Case bearer moths are serious seed pests in clover and related legume seed stands common to Canada, the United States, and Chile. In collaboration with a Chilean scientist a paper was published on their

- biology
- distribution
- taxonomy.

One of the species was recently involved in the contamination of fresh asparagus imports from Chile.

A major volume on eriophyoid mites, their biology, natural enemies, and control, was published in the *World Crop Pests* series by Elsevier Science B.V. This book compiles and synthesizes current world knowledge on the 3000 species of the economically important group of plant-feeding mites.

The pine shoot beetle is a major pest introduced into the United States in ship dunnage in 1992 and found in southern Ontario in 1993. There are 11 species of native parasites and predators associated with it. The taxonomy of these valuable parasites and predators was completed. This work will contribute to the understanding of the role of native parasites and predators in the management of this exotic pest.

A synopsis of the leafhoppers and spittlebugs of 100 tallgrass prairie sites has been published. These small and widely dispersed sites in southern Canada and northern United States are highly endangered. Northern tallgrass prairies have

- 72 species of leafhoppers
- 7 of plant hoppers
- 2 of spittlebugs.

These insects are found only on prairies and hence are important indicators of site quality.

Canadian Collection of Fungal Cultures (CCFC) The fungal genetic resources in the collection (10 500 isolates representing 2500 species) were made readily available to the scientific community for research activities by establishing a home page on the Internet (<http://res.agr.ca/brd/ccf/>).

Taxonomic Information Systems (TIS) This working group has played a facilitating role (in cooperation with CanSIS), in the implementation of Web technologies across the Research Branch. TIS has released on the Internet in an attractive and user friendly format the following databases and electronic publications during the past year

- *The Canadian Poisonous Plants Information System*
- *Poison Ivy, Western Poison Oak, Poison Sumac*
- *Diptera types in the Canadian National Collection of Insects*
- *The Canadian Collection of Fungal Cultures*
- *The Directory of Canadian Culture Collections*
- *Biting flies attacking man and livestock in Canada*
- *Catalogue of Type Specimens in the Vascular Plant Herbarium (DAO)*
- several newsletters and other Internet documents.

These publications integrate the results of highly specialized systematic research projects into information products that can be accessed anywhere through the Internet.

Soil conservation and sustainable land management Information on yield performance over time is fundamental to the evaluation of sustainable land management systems. Trends in spring wheat and canola yield, and yield variability, were calculated and mapped for the 1973 - 1993 period in Saskatchewan and Alberta. In most areas, yield and variability remained stable, but in east-central Saskatchewan fallow - canola yields increased and variability decreased, implying a win-win situation. On the other hand, in west-central Alberta a nonsustainable situation of decreasing yields and increasing variability was identified.

A new method of monitoring the state of organic matter in soil, based on the extraction of lipids with diethyl ether and chloroform, has proven to be as effective and cheaper than previously used methods. This technique allows rapid evaluation of the impact of tillage on soil organic matter quality.

A methodology was developed

- for collecting data on farm-level indicators of sustainable land management
- monitoring their status via observation.

This development of expert systems routines will enable researchers to acquire consistent and reliable information on the relationships between land use and soil quality at the local level.

Support was provided for the application of the *Cropping Systems Identification from Remote Sensing* methodology in King's County, NS. Results helped resolve land use planning conflicts in the municipality.

Expert system modules were developed to determine the status of

- indicators of farm-level soil degradation
- crop yield impacts
- remedial management practices.

The integration of the degradation module with an agro-ecological resource area (ARA) map was tested in Saskatchewan. This work will assist in scaling up local information to regional estimates.

Soil and water quality Time zero (baseline) data collection and documentation for all 23 soil-quality benchmark sites across Canada was completed. Baseline data include

- chemical data
- physical data
- mineralogical data
- yield data.

Soil and contour maps of the sites are also included. Eight of the sites also have automated weather stations. This database, designed to enable long-term monitoring of soil quality under standard production practices, is recognized as a world-leading initiative.

Optimization of conditions has enabled a high-quality compost to be made from municipal organic waste in less than 35 days, as compared with 1 year by traditional means. In addition, tomatoes grown on the compost had lower levels of heavy metal concentrations than similar fruit purchased at local outlets.

Research aimed at validation of guidelines for the application of municipal waste on agricultural soils has shown that the specific mineral composition of the soil has a significant impact on the retention and liberation of heavy metals into soil water. The implication is that guidelines based on the composition of the waste material may not be appropriate.

Crop and weather data and modeling An archive of daily climate data for over 650 stations in Canada was updated to include 1994 data and installed on the Departmental Agrinet computer system. Climate variables in the database include where available

- daily temperature

- precipitation
- estimated potential evapotranspiration
- snow depth.

These data are readily available for research purposes to scientists all across Canada who have access to the OTTA VAX computer.

A database of daily temperature and precipitation for over 160 locations in Ontario was constructed and compared with vomitoxin levels in grain corn using stepwise linear regression. Initial results show that simple weather variables were able to explain up to 34% of the variation in vomitoxin levels. The goal is to determine whether reliable, real-time predictions of vomitoxin levels can be made on a geographic basis in order to issue advisories to Ontario producers.

The SWATRE (soil water transpiration extended) model was used to estimate water deficits and surpluses during the growing season of a perennial forage crop at 14 locations in Ontario. Our simulations show important spatial and temporal interactions among soil and climatic factors and suggest that each one, including the lower boundary condition, should be properly characterized in soil water investigations.

A United States patent for a precipitation gage to collect solid (snow) and liquid precipitation was issued on 5 November 1996.

Spring wheat yields were simulated with the EPIC (erosion productivity impact calculator) computer model and compared with field data from a 27-year rotation study at Swift Current, Sask. Mean estimated yields were not statistically different from measured ones, and the model accounted for 21 - 57% of the yearly yield variability. Further improvements in yield estimates require changes in EPIC's soil water routine.

Software to produce weather data for input into EPIC and WXGEN (weather generator) from climatological data files was written and made available to researchers on the departmental network. This work will allow for the rapid and consistent integration of climate data into crop and environmental models.

Geographical Information Systems (GIS) Software to reaggregate polygons from one coverage to another was upgraded to allow filters of the source and target data sets. This work provides an improved ability to merge GIS data sets from different sources to assist in land use planning.

National Soils Database (NSDB) Version 1.0 of the Canadian ecostratification database was completed and released, in association with Environment Canada and provincial agencies. This product, which defines and describes ecological zones, regions and districts, builds on the *Soil Landscapes of Canada* database and is used as the framework for federal environmental impact assessments. Other departments and provincial agencies use it as the spatial structure for assessing and managing natural resources.

Version 2.2 of the *Soil Landscapes of Canada* (SLC) was released. This version eliminates a serious flaw in earlier versions regarding an ambiguity in the portion of Canada's landmass covered by water. Now there will be only one way to calculate areas from the SLC database, resulting in greater reliability and consistency of all area calculations, thus improving land use and policy decisions that depend on this database.

A final *Soil Carbon of Canada* map at a scale of 1:6 million was published, and an interim *Soil Carbon of North America* map at a scale of 1:6 million was prepared in collaboration with United States soil specialists. This work represents the first time that soil organic carbon has been systematically determined for all of Canada. The information will be used to determine carbon loss due to agricultural practices and global warming.

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Mandate

Multidisciplinary teams at the Centre for Food and Animal Research (CFAR) carry out research focusing on commercializable and public-good technologies that are oriented to the client or customer. Key results areas include

- safety, quality, and added value of food and nonfood products
- biotechnologies that improve competitiveness of the animal industry and the food sector
- conservation of animal germplasm
- animal behavior - welfare and environmental management.

The cost reductions announced in the February 1995 federal budget will result in the closure of the centre over the 3-year time frame of the budget announcement. Priority programs are being transferred and consolidated at other centres of specialization across Canada.

Resources

The Centre for Food and Animal Research is located on the Central Experimental Farm and has research facilities in seven buildings. The food program has specialized facilities for

- sensory and instrumental evaluation of food
- food microstructure research
- pilot-plant processing.

The facilities for animals and some supplementary laboratories are 14 km away, at the 1100-ha Greenbelt Research Farm in Nepean. The centre operates with 203 full-time equivalents, including 64 scientists, and a total operating budget of \$15.1 million.

Achievements

- *Microbiological safety of liquid egg products*
- *Salmonella control*
- *Food microstructure*
- *Cereal β -glucans*
- *Natural products: structure and functionality*
- *Nurition for Health – An Agenda for Action*
- *Evaluating canola oil in infant formulas*
- *Mycotoxins*
- *Sulfonamides*
- *Halofuginone*
- *Bacitracin*
- *Rumen microbial ecology*
- *Bacteriocins and milk composition*
- *Rumen microbial protein production*
- *Effect of feed additives on methane emissions from lactating holsteins*
- *Molecular characterization of a chicken amylase gene*
- *Disease resistance*
- *Reproduction*
- *Alternative housing for lactating sows and their litters*
- *Reducing crushing deaths of piglets*
- *Cryopreservation of boar semen*
- *Conservation of animal genetic resources*
- *Greenhouse gas release*

Microbiological safety of liquid egg products Current pasteurization conditions used for processing liquid egg products did not adequately destroy the pathogenic bacterium *Listeria monocytogenes*. Added solutes, which are used as cryoprotectants for liquid egg, accentuated the heat resistance of this pathogen. Nisin, a bacteriocin produced by *Lactococcus lactis*, effectively reduced *Listeria* populations when incorporated into liquid whole egg. Combining thermal processing with bacteriocin is a potentially useful approach for ensuring the safety of liquid egg products.

Salmonella control Investigating the microbial profile of chicken litter during composting revealed changes in populations of general groups of enteric bacteria.

Food microstructure Yogurt samples made from soy milk of various origins were studied by extended electron microscopy. The appearance is related to the technological procedure. One kind of commercially available soy milk was found to be free of cell wall fragments. The microstructure of the resulting yogurt resembled that of yogurt made from cow's milk.

Additional work on the microstructure of kefir revealed the distribution of microorganisms in the kefir grains. Microstructure of kefir differed from that of yogurt by an overall finer protein matrix composed of casein particles smaller than those found in yogurt. Reduced hydration of casein at the pH of kefir may be the reason for the difference.

Reexamination of an encapsulation technique for suspensions and emulsion revealed that it is not suitable for milk. The casein micelles sedimented in the agar gel capsules after the milk serum had been replaced with a fixative and, subsequently, with ethanol. The technique, however, is suitable for viscous products such as stirred yogurt.

Cereal β -glucans Viscosity, which is important for physiological effects, is controlled *inter alia* by

- molecular weight (MW)
- structure
- concentration in solution.

Therefore, techniques for rapidly determining these variables in cereal β -glucans were developed. Results:

- oat β -glucan is generally more readily extracted and of higher MW than barley β -glucan
- β -glucan is degraded in the upper gastrointestinal tract of animals and to a lesser extent in people; no structural changes during digestion (in pigs) were noted
- oat and barley β -glucan are consistently structurally different
- gel characteristics were observed in depolymerized β -glucan.

Natural products: structure and functionality Cereal milling fractions have potential as sources of

- natural antioxidants
- nutraceuticals
- antimicrobials
- cosmetic ingredients.

The preprocessing of cereals produces a number of bran-enriched mill fractions, which are being analyzed for

- steryl ferulates (antioxidants, nutraceuticals)
- alkylresorcinols (antimicrobials)
- flavonoids (nutraceuticals, antioxidants, and anticancer agents).

Traditional milling of de-branned wheat produces a germ fraction from which we can isolate and purify

- valuable food ingredients
- nutraceuticals
- vitamins
- antioxidants
- pharmaceutical intermediates.

Separation technologies that will be suitable for scale-up are also being studied to enable efficient recovery of a wide variety of these components from low cereal-processing streams.

Nutrition for Health – An Agenda for Action This report was released to the Food and Agriculture Organization in fulfilment of a commitment made by Canada at the International Conference on Nutrition held in 1992. Authored by a joint steering committee from Health Canada and Agriculture and Agri-Food Canada, the document was endorsed by Ministers David Dingwall and Ralph Goodale in June 1996. *Nutrition for Health, an Agenda for Action* focuses on stimulating and accelerating action by all sectors toward achieving nutritional health for all Canadians.

Evaluating canola oil in infant formulas A new method was developed for determining vitamin E in animal tissues. The direct extraction technique minimizes oxidative loss of the vitamin. It is followed by high-pressure liquid chromatographic analysis on diol columns, giving reliable and consistent analysis of tocopherols and tocotrienols. A new lipid, 3-O-acyl-D-erythrosphingomyelin, was discovered in the plasma of newborn piglets and infants. The lipid was characterized by nuclear magnetic resonance, mass spectrometry, and gas chromatography.

Mycotoxins Mycotoxin fumonisin (FB1) fed to growing-finishing swine caused

- changes in performance
- biochemical abnormalities in the blood
- sphingolipid alterations in tissues.

FB1 at a dietary level of 1 ppm was associated with

- variable feed consumption
- increased variability in carcass quality measurements
- overall negative impact on the productivity of a growing-finishing pig.

These effects may be more severe in swine fed naturally contaminated corn containing other fumonisins or *Fusarium* mycotoxins. In swine, low exposure to fumonisins at 1 ppm could cause monetary losses to the producer and should be of concern to the feed industry.

FB1 affected the cells of the immune system by

- influencing regulatory mechanism of nitric oxide (NO) production
- disrupting sphingolipid metabolism.

The increase in NO production can affect response of immune cells to foreign agents. Further work is required to assess the significance of this finding in animals ingesting FB1.

Research on the detoxification of mycotoxin-contaminated grain led to the development of improved air separation technology to remove heavily contaminated moldy material. This advanced technology is currently being pursued by Canadian private industry to fabricate commercial equipment for world-wide markets.

A broad range of adsorbents have been screened to assess their ability to bind mycotoxins in feed. In collaboration with industry CFAR researchers will use the information to develop improved binding agents as feed additives to reduce the adverse effects of mycotoxin-contaminated feed.

The long-term ingestion of fumonisin B1 (FB1) by dairy cows may result in the transmission of trace amounts of mycotoxin residues into the milk. At exposure levels equivalent to 5 - 20 ppm dietary FB1, concentrations in the range of picograms per millilitre were detected in milk using a highly sensitive enzyme-linked immunosorbent assay method developed in-house.

The ability of deoxynivalenol (DON, vomitoxin) to reduce feed intake in swine may be caused at the peripheral level. A receptor shown to be highly responsive to DON is capable of reducing the hunger response. Animals consequently eat less.

Sulfonamides Sulfonamides are an important class of antibacterial compounds, widely used in veterinary practice. Sulfamethazine, a carcinogen suspect, is an extensively used antibiotic in swine production. It can be effectively extracted by microwave technique from positive samples for residue analysis. The sampling rate using this technique is superior to and more economical than other classical sample preparation techniques that are laborious, time consuming, and expensive. Up to 12 sulfonamides can be extracted using the microwave technique.

Halofuginone Feeding halofuginone, a synthetic antibiotic, at the recommended rate and at up to five times that level did not affect

- the health of laying hens
- egg production.

Bacitracin A simple HPLC method was developed to determine

- the concentration of bacitracin and its derivatives in premix, finished feeds
- the presence of a degradation product known as bacitracin F, a carcinogen suspect.

Rumen microbial ecology Scientists introducing novel strains of bacteria or genetically engineered bacteria into the rumen need sensitive systems to determine

- the success of the establishment of the bacteria
- their effects
- the relationships of these bacteria to existing rumen bacteria
- the fate of the bacteria in the environment.

A comprehensive set of probes based on 16S rDNA genes have been developed for a number of rumen bacteria, especially those considered to be Gram positive. A competitive polymerase chain reaction method has also been developed, to detect bacteria when their numbers are very low. These methods have been used to determine

- the establishment of nonengineered strains of *B. fibrisolvens* in rumen fermenters
- changes in the rumen microbial populations when dairy cattle are fed ionophores.

Bacteriocins and milk composition Bacteriocins are protein inhibitors of bacterial growth. Researchers are developing new technologies that will allow producers to control milk composition, based on the use of bacteriocins.

Bacteriocin production is a common feature of rumen bacteria of the genus *Butyrivibrio*. Research into selected *Butyrivibrio* bacteriocins has included

- isolating and characterizing these compounds
- determining their spectrum of activity among rumen bacteria to identify their potential for modifying dairy production
- cloning genes for the production of promising bacteriocins
- assessing in vitro and in vivo their ability to modify milk composition and to promote colonization by genetically modified rumen bacteria.

Rumen microbial protein production The milk bundle protein (MB1) is a *de novo* protein enriched in the four amino acids that limit milk protein production. When produced at appropriate levels in rumen bacteria, MB1 should

- improve the quality of rumen microbial protein
- reduce ruminant requirements for dietary protein.

The gene encoding MB1 has been cloned in a rumen bacterial plasmid vector and introduced into rumen bacteria. Recombinant rumen bacteria carrying the MB1 gene have been shown to produce the new protein. Studies to further increase MB1 production stability within rumen bacteria are under way.

Effect of feed additives on methane emissions from lactating holsteins Methane emissions from adult lactating holsteins in a 120-cow tie-stall barn were measured over 3 years. An automatic gas-sampling system developed by CFAR staff was used. At the same time milk production increased, and daily feed consumption as well as milk fat content decreased. These results indicate increased feed utilization efficiency. However, a second feeding trial 5 months later showed rumen bacteria might be becoming resistant to monensin.

Molecular characterization of a chicken amylase gene Alpha-amylase is a key enzyme in the breakdown of starch to simple sugars in the digestive tract of the chicken. The enzyme plays an important role in feed conversion. Modern breeds of chickens have been selected for a high biomass conversion capacity. To gain insight into the molecular mechanisms that control the expression of this gene - enzyme system in poultry, researchers

- cloned a chicken alpha-amylase gene
- derived its nucleotide sequence
- expressed the gene in transformed lines of baker's yeast.

Disease resistance Mastitis is a multifactorial disease of complex etiology, which despite elaborate farm management schemes, costs the Canadian dairy industry \$500 - 700 million annually. Supplementing the diets of cows with vitamin E reduced the incidence of mastitis by 26% and duration of mastitis by 50%.

Research was carried out on DNA polymorphism as a potential predictor of disease resistance in dairy cattle. An association was found between DR 3 alleles and milk somatic cell count, which is an indicator of mastitis. This information should help in producing genetically healthier cattle. Commercial producers will benefit economically in terms of

- reduced costs for disease treatment
- improved performance.

Reproduction Increase in lifetime reproduction of livestock is highly desirable but difficult to investigate using farm animals. Transgenic mice with rat growth-hormone were used instead as a livestock model, to study the lifetime reproduction performance in mice with and without the transgene. Sustaining a long reproductive life and producing a large number of progeny during a lifetime were found to depend on

- rhythmicity of parturition intervals
- physiological balance.

Alternative housing for lactating sows and their litters We have developed and are testing a number of alternative housing systems for lactating sows and their litters. These systems allow for

- much more freedom of movement for both sow and litter
- the formation of multi-sow and multi-litter groups.

Besides these welfare advantages, these systems provide a level of productivity at least as high as more traditional confined systems for lactating sows.

Reducing crushing deaths of piglets Crushing of piglets by the sow represents a major source of loss for farmers. Until now, however, almost no work has been done on determining how the behavior of sows and piglets contribute to crushing deaths. Our work has now

- identified a number of sow body movements that crush piglets
- found that the way piglets get crushed is influenced by the design of the farrowing accommodation.

This work suggests specific changes in design could help reduce crushings. We have also found that some piglets behave in such a way as to make them more likely to be crushed. These crushings may be reduced through improved management procedures. We have also begun work on the vocalizations produced by piglets when caught under the sow, and why sows sometimes fail to respond to these calls.

Cryopreservation of boar semen A study was undertaken to lessen the detrimental effects of free radicals on semen during equilibration and processing. From several compounds tested, the incorporation of superoxide dismutase resulted in improved survival of frozen-thawed boar sperm.

Conservation of animal genetic resources All encompassing and current data bases on dwindling domestic animal genetic resources have been created, published, and distributed across Canada. This indispensable publication will aid the rare animal conservation groups to prevent erosion of the gene pool.

Greenhouse gas release Emissions of methane (CH₄) and carbon dioxide (CO₂) from a shallow-gutter 118-cow dairy-cattle barn and a 3-m-deep slurry storage tank were determined by continuous monitoring. The mean 24-h barn emissions of CH₄ and CO₂ per cow were 587 and 6137 L, respectively, over a 112 days. Cumulative biogas production in 118 days from batch-stored slurry under confined conditions during summer was 1.34 L per litre of slurry with an average 27% CH₄ content. Farm-tank-stored slurry in cold climatic regions is unlikely to release significant quantities of CH₄ and CO₂ into the atmosphere.

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Mandate

The lead site of the Cereal Research Centre at Winnipeg develops superior wheat and oat cultivars for the Canadian prairies. The centre supports cereal-breeding programs at research centres across western Canada with research in

- biotechnology
- plant pathology
- cereal chemistry
- cereal genetics
- quality evaluation.

At Winnipeg researchers also

- develop improved methods to maintain the quality and safety of stored grain and grain products
- provide screening for regional disease resistance and quality to cereal development programs for the prairies.

At Morden researchers develop improved cultivars and better production and protection practices for the prairie region for flax and field peas. Researchers also

- develop landscape plants for the prairies
- maintain germplasm of alternative crops and winter-hardy woody ornamentals.

Resources

The facilities of the Cereal Research Centre's lead site are situated on the Fort Garry campus of the University of Manitoba in Winnipeg and include

- research laboratories
- greenhouse facilities
- controlled-environment plant-growth facilities
- offices for scientists and administration.

At Winnipeg, field research is carried out at a 103-ha field site at Glenlea, 12 km south of Winnipeg. The Glenlea field station operates only during the summer, but grain storage bins located there are used throughout the year for research on pests of stored grain. At Morden, the land base covers 254 ha.

The new office and laboratory building at Morden includes

- research laboratories
- cold storage
- plant-processing units
- an improved phytotron
- greenhouse facilities
- a pathology containment laboratory.

The Cereal Research Centre has a staff of 135 full-time equivalents, including 45 in the professional categories. It also has 95 term employees. The centre operates with a total budget of \$9.9 million, including \$1.53 million in MII and other special funding programs. The centre also manages an additional \$1.87 million in external funding. Local agricultural inspectors from the Food Production and Inspection Branch and regional offices for the Prairie Farm Rehabilitation Administration are located in the new building at Morden.

Achievements

- *Staff awards and honors*
- *Oat consortium formed*
- *New extra-early hard red spring wheat variety*
- *New amber durum wheat variety*
- *New crown-rust-resistant oat variety*
- *New medium-early high-yield flax*
- *Two new buckwheat varieties*
- *Hope for Humanity rose*
- *Incidence of leaf rust*
- *Stem rust*
- *Location of rust gene*
- *Wheat seed and fusarium head blight*
- *Wheat seed and Septoria leaf and glume blotch*
- *Flame chlorosis*
- *Orange wheat blossom midge*
- *Wheat storage and quality*
- *Incidence of oat crown rust*
- *New genes for resistance to oat crown rust*
- *Rust resistance in Mexican oats*
- *Molecular markers for stem rust*
- *Strawberry fruit rot detected*
- *Potentilla registry*
- *Herbicide effects on field crops*
- *Controlling storage pests with carbon dioxide*
- *Heat production by storage beetles*
- *Flying beetle populations*
- *Storage of wild rice*
- *Rapid insecticidal bioassay*
- *Mycotoxin bioassay*
- *Control of potato aphid on oilseed flax*
- *Tolerance to aphids in cereals*
- *Lygus bugs on Brassicae*
- *Natural Bertha armyworm pesticide*
- *Dehulling flaxseed*
- *Chemistry of flaxseed*
- *Chemistry of buckwheat*

Staff awards and honors Dr. G.H. Gerber has been elected Fellow of the Entomological Society of Canada. The award recognizes Dr. Gerber's contributions to the society and to entomological science in Canada. His research interests and activities have involved

- integrated pest management of pests of canola and mustard
- reproductive biology and physiology of insects
- structure and fate of insect spermatophores.

Drs. R.I.H. McKenzie and D. Leisle were presented with Honourary Life Memberships of the Canadian Seed Grower's Association. The award recognizes the outstanding contributions of these cereal breeders to the Canadian seed industry.

Dr. T. Aung, Dr. N. Howes, Mr. B. Galka, and Ms. D. Jones received an Agriculture and Agri-Food Canada Agcellence award for the development of an efficient doubled haploid wheat production system. The technology has improved the accuracy of genetic studies and greatly accelerated the wheat-breeding program.

Oat consortium formed In 1996, an international group of seed companies and oat milling and processing companies formed the Prairie Oat Breeding Consortium to support oat breeding for the eastern prairies jointly with Agriculture and Agri-Food Canada.

The financial support provided by the consortium will enable the Cereal Research Centre to continue its highly successful oat-breeding program aimed at the development of new disease-resistant oat cultivars with high quality for the farmers of western Canada.

New extra-early hard red spring wheat variety The line BW 191 was approved for registration and will be distributed by Cargill. This high-quality variety offers

- 1.5 days earlier maturity than Roblin, the earliest of the prairie varieties
- 1% higher protein than Katepwa, the most widely grown prairie variety
- good disease resistance
- adaptation to the northern and eastern wheat growing area of the prairies.

New amber durum wheat variety The line DT 484 was approved for registration and will be distributed by SeCan as AC Morse. This high-quality, short-strawed variety offers

- 0.7% higher protein than Sceptre
- greater protein strength than other Canadian durum varieties
- excellent semolina color
- almost 3% higher yield than Kyle
- high resistance to prevalent races of leaf and stem rust
- good lodging resistance.

New crown-rust-resistant oat variety The line OT274 was approved for registration and will be distributed by Cargill as AC Medallion. This white hulled oat has

- high yield
- highly effective resistance to the present crown rust population on the prairies
- good resistance to other oat diseases
- good test weight, kernel weight, percentage plump, and percentage thin
- suitable hull-to-groat ratio, protein content, and oil content.

AC Medallion is well suited to the oat-growing areas of western Canada and, in particular, the black soil zone of Manitoba and Saskatchewan and the brown soil zone of Saskatchewan and Alberta. Its superior crown rust resistance makes it well adapted to areas where rust is a problem.

New medium-early high-yield flax The line FP974 was approved for registration and will be distributed by Saskatchewan Wheat Pool as AC Watson. This flax variety has

- medium early maturity and high yield, particularly in the dry areas of the prairies and in late seeding
- moderate oil content with high oil quality
- medium-large seed size
- good resistance to fusarium wilt
- immunity to rust.

Two new buckwheat varieties Two buckwheat varieties from Morden were approved for registration. The line BS85648 was released to Springfield Mills, Dugald, Manitoba for marketing and production in Canada. This variety, named AC Springfield, has

- large and uniform seed size
- superior large and whole groat producing capabilities.

The line G-1910 has been released to Kade Research, Morden, Manitoba and named Koban. It has

- high yield
- high protein
- high seed density.

Hope for Humanity rose A new rose called Hope for Humanity has been released in conjunction with the 100th anniversary of the Canadian Red Cross. They have been given exclusive rights to the cultivar and will use it for fund raising. The rose has

- 'blood-red' flowers
- excellent repeat blooming, with flowers produced for much of the growing season
- excellent winter hardiness.

Incidence of leaf rust By 1994 the fungus causing leaf rust of wheat had, in Canada,

- increased from 36 virulence phenotypes in 1993 to 38 virulence phenotypes
- increased the phenotypes with virulence to resistance genes *Lr3ka* and *Lr30* from 1% in 1992 to 81% in Manitoba and 74% in Saskatchewan
- not changed virulence phenotypes in Ontario and Quebec from the previous year
- increased the leaf rust severity on Katepwa, a moderately resistant wheat variety, to 40%
- increased the leaf rust severity on the previously resistant variety Roblin to 10%.

Stem rust The pathotype QCC of the fungus that causes stem rust in wheat and barley has increased in prevalence in the northern great plains in recent years. This increase is a result of

- selection pressure exerted by widely grown barley varieties with gene *Rpg1*
- a higher competitive ability of QCC relative to other common races on susceptible barley and wheat.

The degree of receptivity by barley to stem rust is significantly correlated to spore production and infection response. Infection response and latent period are also correlated. Receptivity and urediniospore production are related to the presence or absence of resistance genes.

Location of rust gene In three cereal stem rusts, two cereal leaf rusts, pine rust, and bunt of wheat, the 5 S RNA genes were located in the ribosomal DNA repeat unit. In addition, the flanking sequences were determined in bunt, which contained the TATA sequence in IGR-1 and in the T tracts of the terminator in IGR-2. A region of heterogeneity was demonstrated in the intergenic spacer in wheat stem rust, which may lead to a rapid method for race identification.

Wheat seed and fusarium head blight Germination and emergence of seed from a wheat crop infected with fusarium head blight is improved by

- cleaning, which removes fusarium-damaged kernels and improves grade
- fungicide use, but efficacy depended on wheat variety
- several months storage.

In all cases root mass was reduced, which may affect the plant's vigor.

A new method for trichothecene analysis has been developed. It provides a quantitative measure of the three toxins DON, 15ADON, and 3,15diADON, in grain infected with fusarium head blight. The new method

- is faster
- is less expensive
- has a good recovery rate.

Wheat seed and Septoria leaf and glume blotch This disease affects wheat through

- yield loss
- reduced kernel weight.

Infected seed may cause epidemics. However, using seed from plants affected by *Septoria* had little effect on

- germination
- emergence
- plant vigor.

Fungicide-treated seed performed similarly to untreated seed.

Flame chlorosis Specific vesicles in chloroplasts and mitochondria have been identified as the likely specific sites of the massive, specific RNA replication that characterizes flame chlorosis disease at the cellular level.

Orange wheat blossom midge This organism caused a high level of damage to wheat in Manitoba in 1996.

- At Winnipeg, research plots were 18% infested resulting in at least 20% yield loss. This loss was an increase from 10% in 1995.
- Larvae per head were 3.1 for Brandon, 1.5 for Morden, and 5.8 for Portage la Prairie. Estimated yield loss was 20% or more.
- Unsprayed commercial fields had damage as high as 60% in heavily infested areas and an estimated average of 10% across the affected area.

In earlier research

- Roblin wheat suffered a higher percentage infestation than Biggar
- Roblin and Biggar had similar numbers of damaged kernels per spike
- later planted varieties were significantly less infested but risk of frost damage was increased.

Two possible sources of resistance to the wheat midge have been found and incorporated into the wheat-breeding program, namely,

- a spring wheat with a low proportion of damaged seeds often associated with dead larvae
- eight winter wheat lines that produced a small number of shorter, rounded, ‘tubby’ seeds instead of shriveled seed.

Wheat storage and quality Storage of grain under proper conditions for up to 15 months had little effect upon its bread-making quality. However, although of no consequence to the end user, the small changes may limit comparisons in screening wheat breeders’ lines unless internal controls are used. A test to determine how long grain has been stored may be based on these changes.

Incidence of oat crown rust In Canada in 1994

- 134 virulent phenotypes of the fungus causing oat crown rust were identified in Manitoba and Saskatchewan
- 45.5% of these phenotypes had virulence to both resistance genes *Pc38* and *Pc39*, present in all recommended eastern prairie oat varieties
- in Ontario, 68.5% of the isolated virulent phenotypes were virulent to both genes
- virulences to the newer resistance genes *Pc48* and *Pc68* were detected at low levels
- the gene *PcS42*, newly derived from *Avena strigosa*, was highly resistant to all isolates
- combinations of genes will confer longer-term protection against common virulence phenotypes.

New genes for resistance to oat crown rust Three new genes for resistance to oat crown rust have been identified. One appears to be most useful for the Canadian prairie region. It is

- linked to gene *Pc35*
- different from all other named genes
- assigned the symbol *Pc96*.

Gene *Pc96* should only be used in combination with other effective genes and will be valuable for diversification of resistance genes in oat breeding.

Rust resistance in Mexican oats Stem rust and crown rust are two important diseases in the oat-growing areas of Mexico. Breeding lines and cultivars from Mexico were examined and found to have sources of stem rust and crown rust that are potentially useful, warranting further genetic studies to more closely identify these resistance-conferring genes.

Molecular markers for stem rust Several molecular markers for two stem rust resistance genes have been identified and localized in cultivated oat. As a result

- breeders will now be able to select RFLP and RAPD markers for these genes for use in their selection programs
- the markers will also be useful for monitoring and reducing linkage drag in backcross breeding programs.

An oat avenin clone and an oat globulin clone detected loci that were intimately associated with two rust resistance genes. These clones may have potential as markers for other stem or crown rust resistance genes in members of the genus *Avena* and perhaps other grass species.

Strawberry fruit rot detected Anthracnose fruit rot of strawberry was observed for the first time in Canada in 1994 at Morden. Incidence of rot ranged from 11% on the cultivar Seascape to 82% on the cultivar Fern. The pathogen may have been introduced via transplants imported from California.

Potentilla registry No morphological discontinuities were found among 127 different cultivars, North American accessions, and Eurasian accessions of *Potentilla*, although the group was diverse. While the plants were generally self-incompatible, with the exception of the tetraploid group, gene flow was possible in most directions. The ability to intermate and the lack of morphological discontinuity indicate that all the plants belong to the same species, *Potentilla fruticosa*. Morden has become the international registration authority for this species.

Herbicide effects on field crops Broad-leaved crops differ in their tolerance to low (sublethal) doses of 2,4-D that might occur as spray drift. At the low rates tested

- field peas were unaffected
- buckwheat yields were reduced in one of three years
- lentil and canola yields were reduced in two of three years
- sunflower yields were reduced every year.

Residues of ethametsulfuron, used to control cruciferous weeds in canola, in the cropping year after application

- did not affect navy bean or potatoes
- damaged buckwheat and sunflower
- had no effect on any of the crops in the second year after application.

Effectiveness of metribuzin for wild mustard control in field peas can be affected by cultivar choice. A long-vined field pea cultivar suppressed wild mustard growth more than a short-vined cultivar. This finding suggests less herbicide may be needed with more competitive cultivars.

Controlling storage pests with carbon dioxide Introduction of carbon dioxide into grain storage structures is a pesticide-free method of insect control. Its success depends on uniformity of distribution, as well as maintenance of the gas concentration. In stored wheat bulks, carbon dioxide sublimated from dry ice will

- vary in concentration with the amount of dry ice used
- move more rapidly horizontally than vertically
- become uniform in horizontal concentrations in the top two-thirds of the bulk
- attain higher concentrations if the grain is covered with a PVC sheet
- be sorbed by the grain, affecting concentrations and making allowances essential
- rise in convective flow in hot grain and fall in cold grain
- have a higher convective pore velocity through the grain when introduced from the top
- increase convective pore velocity with temperature when introduced from the bottom
- increase apparent flow coefficient with temperature and amount introduced
- not vary apparent flow with changes in moisture levels.

A model of movement through the bulk during dry ice sublimation and a pure diffusion model that takes into account the effects of sorption and desorption and leakage from the storage structure will predict the carbon dioxide distribution.

Heat production by storage beetles The heat production of adult rusty grain beetles under adiabatic conditions was affected by

- initial grain temperature
- moisture content of the grain
- age of the adult
- adult population density.

Metabolic heat production may be the main cause of hot spots and heating in dry grain. These results will be used in modeling studies.

The lifespan of adult rusty grain beetles was unaffected by development at different temperatures or different densities. However, development at high densities resulted in adults with significantly smaller head capsules.

Flying beetle populations For 7 years, flying beetles associated with stored grain were collected in a suction trap at locations adjacent to grain storage structures. The study found that

- there was little correlation between flying beetle numbers and the weather
- fungivores were the most common flying beetle captured
- granivores occurred at very low frequencies
- rusty grain beetle, flat grain beetle, and red flour beetle were the most common granivores
- catches of flying granivores did not reflect their common occurrence in stored grain.

Infestation of grain by the confused flour beetle will have a greater effect on grain deterioration than infestation with the American black flour beetle. The confused flour beetle multiplies more rapidly than the American black flour beetle and causes significant damage to the grain endosperm and germ and thus results in a more rapid loss in germination.

The presence of both the confused flour beetle and the American black flour beetle in grain lowers the incidence of seed-borne fungi because of the direct consumption or the secretion of quinones that inhibits molds.

Storage of wild rice Safe storage conditions have been defined for wild rice under varying moisture and relative humidity conditions for up to 12 months. Wild rice was also found to be nutritionally superior to Basmati rice for most *Cryptolestes* and *Tribolium* species of storage insects. The potential for insect infestation is severe in heated homes and warehouses.

Rapid insecticidal bioassay A rapid and simple flour disk bioassay has been developed for testing biologically active substances against several species of stored-product insects.

Mycotoxin bioassay A new method for assessing mycotoxin production in cultures of *Aspergelli* and *Penicillia* has been developed. It

- is rapid, convenient, and reproducible
- minimizes human exposure to solvent
- requires little sample manipulation
- does not require special operator training
- allows aliquots of the extract to be saved for further study.

Control of potato aphid on oilseed flax Sequential decision plans have been developed to guide chemical control decisions for the potato aphid on oilseed flax in western Canada.

Control measures are not applied

- at full bloom if there are fewer than 44 aphids on 25 plants
- at green boll if there are fewer than 96 aphids on 20 plants.

Insecticide applications are recommended

- at full bloom if there are more than 106 aphids on 25 plants
- at green boll if there are more than 224 aphids on 20 plants.

If aphid numbers are intermediate at either stage, increase the number of plants sampled to 50. If the threshold numbers are now exceeded, control measures are advised.

Tolerance to aphids in cereals Breeding tolerance of insect pests into cereals is preferred to antibiosis, because this approach is less likely to lead to selection of pests that can overcome the plants resistance. For three cereals with different levels of antibiosis

- the cereal plants showed no differential tolerance to two species of aphid
- biomass conversion was constant at 3 mg plant loss per milligram of aphid biomass gain.

Lygus bugs on Brassicae Adult *Lygus* bugs fed 5–10 times less frequently on seeds within pods of white mustard than on seeds within pods of canola. This preference was attributed

- partly to the presence of long sharp spines (trichomes) on the mustard pods
- mainly to the high concentration of the glucosinolate ‘sinalbin’ in the seeds.

This will have consequences for the development of low-glucosinolate lines of mustard for the oilseed market.

Natural Bertha armyworm pesticide One strain of *Bacillus thuringiensis* spp. *aizawai* (Bt) was highly toxic to Bertha armyworm, compared with the Bt international standard. It was synergistic with lines of *B. thuringiensis* spp. *kurstaki* and *B. thuringiensis* spp. *kenyae* alone or together when fed as powders to third instars in an artificial diet. When cultured together, only the *aizawai* and *kurstaki* strains were synergistic.

The potency of the spore-crystal product of the *B. thuringiensis* spp. *aizawai* strain was enhanced by the addition of 0.5% wt/vol NaCl and 0.1% vol/vol Tween 60 to the culture medium containing cottonseed meal and glucose. The amino acid L-cystine in the media is contraindicated.

Dehulling flaxseed A simple dehulling procedure for assessing dehulling quality in a flaxseed-breeding program has been developed using the tangential abrasive dehulling device (TADD).

- The method discriminates between cultivars.
- Hull recovery and rate constant are affected by speed and dehulling time.

- Hullability varied between cultivars 50–91% with an extraction rate between 73–80%.
- Hullability was improved by reducing the moisture content and storing for 24 h.
- Seed weight and oil content were major factors in dehulling quality.

Chemistry of flaxseed Variations in the flavonoid and phytic acid content of flaxseed meal occur mainly because of the cultivar and its interactions with location and year. The meal contained flavonoids at 35–71 mg/100 mL and phytic acid at 23–33 g/kg. Scientists found that

- flavonoid content is inversely related to protein content and weakly to oil levels
- phytic acid content is independent of oil level and not related to seed yields
- phytic acid content is inversely related to iodine value and phenolic acids
- no difference in flavonoid content existed between transgenic lines and their nontransformed parent
- stability of phytic acid appears genetically controlled.

Flaxseed gums from yellow-seeded lines exhibit stronger rheological properties than gums from brown-seeded lines. The rheological properties of flaxseed gums were affected by

- diversity in monosaccharide composition
- neutral polysaccharide (arabinoxylans) content causing shear thinning flow and ‘weak gel’-like properties
- acidic polysaccharide content causing weaker rheological properties typical of a viscoelastic fluid.

Chemistry of buckwheat Variation in the flavonoid, rutin, antioxidative activity, and phenolic acid content of buckwheat occur mainly because of the cultivar and its interaction with its environment. In buckwheat

- flavonoid content correlates with rutin content
- flavonoid content and antioxidative activity is weakly correlated
- phenolic acid content is independent of seed color and protein content.

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Mandate

The Brandon Research Centre has been designated as a national centre of expertise for land resource management in western Canada. A multi-disciplinary team of scientists has been assembled to develop sustainable management systems for the Parkland, a vast agro-ecological region of the Canadian Prairies. This research team will advance scientific knowledge and deliver innovative technologies in the areas of

- resource conservation and production systems for the Black and Gray soil zones
- varietal development of barley
- livestock and pasture management
- manure management.

Resources

The Brandon Research Centre is one of the five original experimental farms established by the federal government through an act of Parliament in 1886. The land base covers 862.7 ha owned and 443 ha rented. In 1996-97 the staff comprised 67 full-time equivalents, including 14 scientists. The centre operates on a budget of \$5.3 million.

The new office and laboratory building includes

- modern research laboratories
- computer-controlled environment chambers and greenhouses
- long-term cold-storage units
- a library and information centre
- conference rooms
- offices.

Local staff from the Prairie Farm Rehabilitation Administration, Food Production and Inspection Branch, and Canadian Grain Commission are also located in the building.

The Brandon Research Centre is formally linked with the Manitoba Land Resource Unit in Winnipeg.

Achievements

- *Staff awards and honors*
- *Function of pregnancy-specific protein B*
- *Methane production by beef cattle*
- *Pasture-finished beef*
- *Grazing alfalfa - grass pastures*
- *New barley varieties*
- *Identifying new resistance genes in barley*
- *Genetic control of important traits in barley*
- *Reducing volatile losses from urea fertilizers*
- *Fertilizer effects on cadmium content of malting barley*
- *Reducing herbicide use in conservation tillage*
- *Decision support system for weed management*
- *Tillage and cropping effects on nitrogen fixation*
- *Row spacing and seeding rate effects on wheat and barley*
- *Long-term benefits of fertilization*
- *Residue decomposition rates*
- *Precision farming*
- *Avoiding spray drift in sunflowers*
- *Using field pea competitiveness to suppress wild mustard*
- *Manitoba soil data go digital*
- *Salinity risk index*

Staff awards and honors Mr. R.G. Eilers was one of 15 team members receiving the Agcellence '95 Award for completion of a project resulting in a significant contribution to the agriculture and agri-food sector. This departmental award was given in recognition of the outstanding publication *The Health of our Soils: Toward Sustainable Agriculture in Canada*.

Mr. H. Veldhuis was presented the Environmental Award '95 for dedication and commitment to protected areas. This award by the Canadian Council on Ecological Areas recognized his contributions as a member of the Ecological Stratification Working Group who produced the map and report *A National Ecological Framework for Canada*.

Dr. D.A. Derksen was the western Canada recipient of the 1996 Excellence in Weed Science Award sponsored by DowElanco Canada Inc. and presented at the Annual Meeting of the Expert Committee on Weeds in Victoria, B.C. This award recognizes exceptional contributions to Canadian weed science. His research on weed and crop ecology has played a major role in developing a systematic, long-term approach to weed management in reduced tillage cropping systems.

Function of pregnancy-specific protein B Experiments on cultured luteal cells from beef cows identified the physiological functions of pregnancy-specific protein B. During the middle and late stages of the estrous cycle, pregnancy-specific protein B stimulates the corpora lutea to produce prostaglandin and progesterone but not oxytocin. Knowing more about endocrine function in the maintenance of pregnancy will hasten the development of new technology for improving reproductive efficiency of beef cattle.

Methane production by beef cattle Tests were done to determine the amount of methane produced by cattle in their natural environment. Methane is a gas that has been implicated in global warming. Neither grazing system nor stocking rate affected voluntary feed intake or methane production by yearling steers grazing alfalfa - grass pastures. The steers produced a daily average of 0.69 L of methane gas per kilogram of body weight. Energy lost through eructation averaged 8.9% of gross energy intake. Administration of a monensin intra-ruminal controlled-release capsule was not effective in reducing methane production by steers.

Pasture-finished beef Grazing trials showed that productive alfalfa - grass pastures could be used to finish beef of acceptable quality to meet Canadian A-grade standards. However, a short 33-day period of grain feeding increased the degree of marbling and produced more desirable meat color. Pasture finishing did not result in yellow fat. Sensory (taste panel) evaluation did not detect any differences in tenderness or flavor between pasture-finished and grain-finished beef.

Grazing alfalfa - grass pastures The productivity of alfalfa - grass pastures was assessed for effects of

- grazing system
- stocking rate.

Length of the grazing season was shorter on continuously grazed pastures, especially at high stocking rates. Carrying capacity was greater on heavily stocked rotationally grazed pastures versus heavily stocked continuously grazed pastures. Cattle gained more per day and per hectare at low versus high stocking rates. Total live weight production was greater at high versus low stocking rates. There was no difference in forage production, except in the last (fourth) year of grazing trials when productivity was highest for heavily stocked pastures. Alfalfa content of the pastures at first increased and then declined as the percentage of grass increased. Animal production was high regardless of grazing system and stocking rate, indicating that pastures dominated by alfalfa appear useful for backgrounding stocker cattle.

New barley varieties The line BT377 was recommended for registration and named AC Rosser. It will be marketed by SeCan Association. AC Rosser is a six-row feed barley that is

- superior in yield and straw strength to Brier, the check variety
- equal to Brier in other traits
- suggested as a replacement for Brier in the eastern prairies, being well adapted to this region.

The line HB103 was approved for registration and will be marketed as AC Hawkeye by Prairie Pools, Inc. This six-row hulless barley has

- better kernel quality than Condor, the check variety
- high yield potential, particularly in the drier areas of the prairies
- potential for use in the food industry, being eligible for the Canada Western Select Hulless food grades.

Identifying new resistance genes in barley Recent changes in the virulence patterns of barley pathogens prevalent in Canada have necessitated the search for new sources of genetic resistance in barley. Evaluation of 176 Turkish barley accessions indicated that this germplasm is a good source of resistance to

- *Septoria passerinii* (speckled leaf blotch)
- *Rhynchosporium secalis* (scald)
- the spot-form of *Pyrenophora teres* (net blotch).

A small number of accessions were identified with resistance to the net form of *Pyrenophora teres*.

Genetic control of important traits in barley An intensive study was done in collaboration with the North American Barley Genome Mapping Project. It revealed the types and distributions of quantitative trait locus effects for seven agronomic traits in a two-row barley population (Harrington/TR306). A 127-point base map was constructed from molecular markers in 146 doubled haploid lines. The results will provide barley breeders with opportunities for future testing of marker-assisted selection affecting

- grain yield
- days to heading
- days to maturity
- plant height
- lodging severity

- kernel weight
- test weight.

Reducing volatile losses from urea fertilizers Urea and urea ammonium nitrate are commonly used fertilizers on the Canadian prairies. Both fertilizers are subject to volatile losses of ammonia when applied to the soil surface. These losses can be reduced by fertilizer banding or incorporation, practices which are undesirable under reduced tillage. In field studies, the use of *n*-(*n*-butyl)thiophosphoric triamide or NBPT, a urease inhibitor, was effective in reducing ammonia volatilization from surface-applied urea and urea ammonium nitrate. Ammonium thiosulfate proved to be a relatively weak urease inhibitor, as it had little effect on ammonia losses from urea ammonium nitrate.

Fertilizer effects on cadmium content of malting barley Cadmium occurs naturally in soils and as a contaminant in some fertilizers. Field studies determined that cadmium in the grain of malting barley was increased by applications of

- ammonium nitrate
- monoammonium phosphate
- potassium chloride fertilizers.

The increase in cadmium accumulation was not primarily related to addition as a fertilizer contaminant. Fertilizer salts may elevate cadmium solubility and concentration in the soil solution, increasing availability for crop uptake. Higher crop yields associated with nitrogen application may also increase cadmium accumulation through more extensive rooting and greater mass flow.

Reducing herbicide use in conservation tillage Difficulty with weed control and increased use of herbicides may jeopardize the long-term sustainability of conservation tillage. Twenty-seven site years of data collected since 1985 in eastcentral Saskatchewan showed that crop rotation had a bigger impact on weed communities than did tillage system (conservation versus conventional). Grouping weed species by perennation did not explain the response of species to tillage system. Further study found that changes in weed community dynamics can be managed by varying selection pressure. By careful consideration of crop rotation, conservation-tillage farmers can reduce their herbicide inputs.

Decision support system for weed management Under the Parkland Agricultural Research Initiative, a new decision support system called the *Weed Management Planner* was developed for farmers practicing conservation tillage in western Canada. It stresses the integrated weed management principles of

- crop rotation
- herbicide rotation
- use of thresholds for crop loss.

This software program provides short-term management options and long-term management strategies to manage weeds and avoid adverse changes in weed communities due to the adoption of conservation tillage. Unique in its approach, the program comprises modules on

- weed scouting
- long-term weed management
- problem weeds
- crop loss
- herbicide planner
- weed identification.

Tillage and cropping effects on nitrogen fixation In field trials with lentils and peas done with the University of Saskatchewan, nitrogen fixation was measured to determine possible effects of

- tillage system
- crop rotation.

Nitrogen fixation was higher

- under zero tillage than under conventional tillage
- for lentils grown in diversified crop rotations under both tillage systems.

This study is the first research in western Canada to show differences in nitrogen fixation between tillage systems and to point out that cropping history plays a role in nitrogen fixation.

Row spacing and seeding rate effects on wheat and barley Adoption of conservation tillage on the Canadian prairies requires fine tuning of production practices. With conventional tillage, grain yield is generally thought to decrease as seed row spacing increases. This observation is not necessarily the case with zero tillage.

In a study using a conventional-tillage fallow-cropping system, varying seed row spacing did not affect the yield of spring wheat or barley. Grain yields improved by 14% in wheat and 32% in barley with higher seeding rates. There was no interaction between row spacing and seeding rate, suggesting that adjustments in seeding rate are not required with changes in row spacing.

The presence of surface residue and standing stubble cannot explain the lack of a row-spacing effect under a zero-tillage stubble-cropping system when results are similar under conventional-tillage fallow management.

Long-term benefits of fertilization A controlled-environment experiment for improving soil fertility and yields in annual cropping systems substantiated the importance of

- applying nitrogen and phosphorus fertilizers
- reducing fallow frequency
- including legumes in rotation.

The findings also emphasized the need to apply phosphorus in legume-containing systems to maximize crop production.

Residue decomposition rates Crop residues lose their ability to protect the soil surface and reduce soil erosion as they decompose. Predicting these changes requires an understanding of how climatic factors interact in controlling rates of residue decomposition. To this end, the residue-decomposition submodel of the *Wind Erosion Prediction System* was evaluated. The temperature and water functions, which are being used with easy-to-obtain weather data, were found to give reasonable estimates of loss from surface residues over a range of environments.

Precision farming A collaborative study led by the Saskatoon Research Centre and done with the University of Saskatchewan examined variable-rate application in

- flax
- spring wheat
- canola.

Precision farming was found to enhance the efficient use of nitrogen fertilizer. Variable-rate application based on soil organic carbon or topography increased yield response to fertilizer more than either conventional (uniform) application based on soil test recommendations or variable-rate application based solely on soil levels of residual nitrogen. As the subhumid Parkland region accounts for 85% of the nitrogen fertilizer used in western Canada, farmers in this area may benefit most from the new technology.

Avoiding spray drift in sunflowers Herbicide trials confirmed that imazethapyr doses with active ingredient greater than 1.5 g/ha (3% of the recommended dose) can cause severe injury to sunflowers. In western Canada, imazethapyr is registered for control of annual weeds in

- alfalfa

- dry beans
- field peas
- tolerant canola varieties.

While low doses of imazethapyr that occur as spray drift may not reduce sunflower yields in most years, the potential for severe yield losses and reduced oil content exists. Producers are advised to use caution when applying imazethapyr in fields next to sunflowers.

Using field pea competitiveness to suppress wild mustard Field studies investigated the effect of variety selection on field pea competitiveness with wild mustard. Varieties having both long vines and rapid canopy development were more competitive with wild mustard than those with short vines and slow canopy development. Varieties differed markedly in their ability to suppress weed growth. Those that more effectively reduced wild mustard density or biomass had the lowest yield losses. However, there were no differences among varieties under high weed pressure and when weeds emerged 1 week before the crop.

Manitoba soil data go digital Most of the soil map information for agricultural land in southern Manitoba has been computerized and will be available in a GIS (Geographical Information System) environment on a rural municipality basis. This digital database will greatly enhance the utility and flexibility of soil and land resource information for making better informed policy and land management decisions on issues related to sustainable agriculture.

Salinity risk index A methodology was developed to monitor and evaluate the potential impact of agricultural practices on the sustainability of soil quality in the Canadian prairies. The salinity risk index has been accepted as a component indicator of soil degradation by the national Agri-Environmental Indicator Project of Agriculture and Agri-Food Canada. This methodology provides a systematic framework for evaluating the risk of salinization at broad scales. It has been well received at both national and international levels.

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Mandate

The Saskatoon Research Centre and its research farms bring a long-term commitment in crops research to the agri-food industry in western Canada. The centre's deliverables are

- improved germplasm of oilseed and forage crops
- crop production and pest control practices for the Parkland region
- research to expand the utilization of prairie crops.

Each program has strong input from biotechnology and chemistry. A component of the crop utilization research is located within the POS Pilot Plant Corporation in Saskatoon.

Resources

The main office-laboratory building and the greenhouse-growth chamber complex are located on the University of Saskatchewan campus. Saskatoon is emerging as a major world centre for agricultural biotechnology and our location encourages collaboration with other research establishments, public and private. Offices, laboratories, and shops service the programs at Scott and Melfort. Total full-time equivalents comprises 144, including 45 professionals. The centre manages a budget of \$10.8 million. The Saskatoon facility is currently being upgraded at a total cost of more than \$30 million.

The centre has a 242-ha field site 5 km northeast of the university. The Scott Research Farm is 160 km west of Saskatoon, with a land base of 349 ha. Scott also manages field sites at Lashburn and Loon Lake. The land base at the Melfort Research Farm, 200 km northeast of Saskatoon, consists of 371 ha near the city of Melfort.

Achievements

- *Staff awards and honors*
- *We're wired*
- *AC Boreal - the first synthetic Polish canola*
- *Mapping resistance to blackleg*
- *Controlling Bertha armyworm biologically*
- *Stretching the canola season*
- *Canolab project supports education*
- *Monitoring pests*
- *Wheat midge is selective*
- *Alfalfa to reduce bloat in cattle*
- *Bark-scraping to control brush*
- *Computerized support for decision-making by producers*
- *Flax has medical potential*

Staff awards and honors Dr. Ashley O'Sullivan, Director, received the Association of Professional Executives (of Canada) award for leadership.

Dr. Keith Downey, emeritus scientist, was inducted into the Saskatchewan Agricultural Hall of Fame in 1996 for his contribution to converting rapeseed into canola.

We're wired Saskatoon Research Centre now has a site on the World Wide Web! Visit us at <http://res.agr.ca/sask/mainpage.html> Find out about our staff expertise, resources, recent results and products, and ongoing research interests. We post research letters, insect forecast maps, and collaborative opportunities.

AC Boreal - the first synthetic Polish canola AC Boreal, our first synthetic Polish canola, was registered for commercial release. Synthetic canolas are mixtures of two parental lines or populations which together display greater stability than either of the parents. This technology was developed at Saskatoon and has already been utilized by canola seed companies.

Mapping resistance to blackleg Blackleg of canola, a fungal disease causing yield losses, is widespread throughout canola-growing areas of western Canada. In the quest to develop blackleg-resistant canola, researchers have used biotechnology to map the gene. Results strongly suggest that a single major gene in the spring oilseed rape cultivar Cr  sor controls resistance to blackleg in the adult plant.

Controlling Bertha armyworm biologically Bertha armyworm is a serious pest of canola. Yield losses estimated at \$30 - 60 million occurred even though control measures costing \$45 - 50 million were undertaken. The larvae can cause drastic yield losses by eating leaves and, particularly, seed pods. A natural virus, known to infect and kill Bertha larvae, is being tested for use as an inundative biological control agent. Field results to date, although variable, have shown promise. Researchers are working to determine if the use of this virus offers a cost-effective control method.

Stretching the canola season The practice of seeding canola in late fall (late October) or very early spring (late April) is being tested at the Scott Research Farm. Earlier crop maturity is the main advantage of this strategy. Gains have been seen in the order of 1-3 weeks compared with conventional seeding of canola in mid-May. This dramatically reduces the risk of fall frost damage. Successfully established fields

- produce larger seeds
- have higher oil content

- have reduced weed competition
- have reduced risk of late summer insect damage.

The benefits may be offset by premature germination, which can lead to loss of the entire crop.

Canolab project supports education The centre is contributing to a national project in support of science education. Several thousand classes between grades 4 and 6 across Canada are growing canola in their schools this year. Canadian astronaut Dr. Bob Thirsk took AC Excel canola seeds to outer space on a recent flight of the space shuttle Columbia. The students are learning about scientific method by comparing space-flown canola seeds to control seeds that stayed on earth. This opportunity allows them to study the environment in outer space, as well as plant growth and development. Centre staff are assisting in the development of much of the supporting material for the teachers.

Monitoring pests Surveys track the spread and level of crop pests. A survey of weeds in Saskatchewan crops was completed this year in cooperation with industry and the province. Over 120 weeds were identified during the process of surveying nearly 1200 cereal, oilseed, or pulse fields. Maps of 38 of the most frequently occurring weeds provide a picture of the size and extent of weed populations within various ecoregions of the province. Results of this survey when evaluated with data from previous and other surveys

- track the spread of weeds
- link changes in weed populations to production practices.

With the collaboration of the Prairie provinces and industry we prepared infestation and forecast maps for

- grasshopper
- Bertha armyworm
- orange blossom wheat midge insect.

Although these maps do not eliminate the need to monitor individual fields, they are valuable as planning tools to extension staff, producers, and the crop protection industry. All pest distribution maps are widely distributed using our site on the world wide web.

Wheat midge is selective Infestations of wheat midge caused serious reductions in yield and grade in wheats in 1996. Hard red spring wheats are susceptible to midge damage throughout heading, but damage rarely exceeds 3% when egg-laying occurs after the anthers are visible. Chemical control is usually warranted when one adult midge is present on every four or five wheat heads at several locations in the field. Producers should avoid planting hard red spring wheats where midge damage occurred the previous year.

Midge damage varies substantially according to variety of spring wheat. Damage in hard red spring wheat, durum wheat, and strong gluten wheat increased as days to heading increased. Early-maturing varieties were exposed to fewer female midge than later-maturing varieties, and so suffered less damage. Prairie spring wheats followed the opposite trend. Damage was significantly higher in early-maturing varieties such as Oslo and Cutler than in late-maturing varieties such as Biggar and AC Taber.

Alfalfa to reduce bloat in cattle Bloat is a potentially fatal digestive disorder afflicting cattle that feed on alfalfa. It is estimated to cost the Canadian cattle industry \$55 million annually in treatment and preventative measures. Researchers at Saskatoon Research Centre have developed alfalfa that reduces bloat in cattle by slowing the rate of digestion. In field trials, alfalfa resulting in a low initial rate of digestion, reduced the incidence of bloat by 40 - 90%. Commercialization of this bloat-reduced alfalfa will begin in 1997.

Bark-scraping to control brush The clearing of land for settlement and agriculture promoted aspen suckering and the invasion of woody shrubs. These species, which reproduce by creeping roots, continuously encroach into pastures to plague beef producers throughout the aspen Parkland region of western Canada. Bark-scraping is as effective as both mowing and fire in the management of aspen. Bark-scrapers may be constructed from used grader blades, I-beams, or railroad rails. Used as recommended, these scrapers, pulled with a cable by a standard or small crawler tractor, provide producers with a moderately priced and readily available means of controlling brush.

Computerized support for decision-making by producers Conservation production systems are being developed

- to reduce risk of soil degradation
- to improve the economics of crop production.

These systems are complicated, often requiring the producer to weigh potential risks against possible gains. The Parkland Agriculture Research Initiative (PARI) has supported the development of a computerized decision-support system to facilitate on-farm decision-making consistent with conservation farming practices. The system accesses information from several sources and, through interaction with the user, indicates the level of risk associated with certain production options. The system includes a record-keeping segment. Advice is provided on

- crop rotation
- variety selection
- fertilization
- pest identification and control choices
- machinery to manage residue.

Flax has medical potential Flaxseed products commonly are available on the shelves of health-food stores. Scientists have developed extraction processes for an ingredient of flax called secoisolariciresinol diglucoside or SDG. Medical research collaborators at the universities of Western Ontario and Saskatchewan are conducting trials to determine if SDG relieves the symptoms of various diseases, including

- lupus nephritis
- diabetes
- atherosclerosis.

Presentations have been made to several companies, both Canadian and international, in the search for potential partners to commercially develop this technology.

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Mandate

The Semiarid Prairie Agricultural Research Centre (SPARC) has been designated as a national centre for research on dryland farming systems. It has the mandate to conduct research and development in

- resource conservation (land)
- cereals
- forages
- field crops.

The Land Resource Unit researches the state of the regional land resource base and the dynamic factors that affect it. Its objectives are to

- develop and maintain up-to-date land resource databases
- provide interpretations of land use suitability
- provide assessments of agri-environmental sustainability
- provide a basis for the regional application of research findings.

Resources

In 1996-97 the Semiarid Prairie Agricultural Research Centre (SPARC) began with 104 full-time equivalents, including 24 professional staff, and a total operating budget of \$7.7 million. SPARC also receives more than \$2 million support from private industry and from other targeted government funding programs. The total land base is about

- 907 hectares in Swift Current
- 490.1 hectares in Indian Head
- 53 hectares in Regina.

Facilities include a modern office–laboratory building equipped with

- growth rooms
- greenhouses
- a salinity research lab
- a crop services building
- a breeders' seed production and distribution centre at Indian Head
- a well-equipped machinery design and production facility.

Achievements

- *Commercial production of wheat varieties*
- *Four new wheat varieties registered*
- *Rapid protein selection*
- *Disease-resistant wheats*
- *Environment and genotype affect characteristics of dietary fiber in rye*
- *Collaborations with US scientists in study on C dynamics*
- *Improved dryland alfalfa production*
- *Salinity tolerance*
- *Ground water protection*
- *International modeling effort*
- *Zero tillage enhances carbon sequestration in the soil*
- *Use of fertilizers fosters agricultural sustainability*
- *New alfalfa variety*
- *Shiny plants make better seed*
- *Nitrogen-supplying power and fertilizer recommendations*
- *Nitrogen management for sustainable crop production*
- *Factors affecting carbon storage in soils*
- *Crop models and decision-support systems*
- *Soil phosphorus may leach in prairie soils*
- *Health of Our Soils report*
- *Ecological land classification*
- *Soil inventory of Saskatchewan completed*
- *Suitability ratings for irrigated potatoes and beans*

Commercial production of wheat varieties Two varieties are poised for significant commercial production in 1997:

- Canada Western Red Spring variety AC Barrie
- Canada White Prairie Spring variety AC Karma.

Producers are enthusiastic about the potential for both varieties, and the Canadian Wheat Board has strong customer interest in AC Karma as an alternative to other white wheats available in the marketplace.

Four new wheat varieties registered Four new varieties with improvements in grain yield and quality were registered in 1996 and tendered to seed companies for distribution to producers. Two Canada Western Red Springs, AC Elsa and AC Cadillac, and the Canada Red Prairie Spring variety AC Crystal received full registration. The Canada White Prairie Spring variety AC Vista received interim registration and is undergoing market assessment in cooperation with the Canadian Wheat Board.

Rapid protein selection Near-infrared equipment commonly used by the Canadian Grain Commission and elevator companies for testing protein on commercial grain was purchased. The acquisition ensures that protein selection in the Swift Current, Lethbridge, and Winnipeg breeding programs is compatible with industry standards. This technology

- allows breeders to rapidly measure protein on thousands of breeding lines
- reduces the cost of developing new varieties such as AC Barrie, which has set a new standard for high yield and high protein.

Disease-resistant wheats Genetic resistance to diseases increases producers' earnings by

- reducing the use of fungicide chemicals
- improving grain yield and quality, while being environmentally friendly.

Conventional and molecular genetic tools are being developed and applied to identify lines in the breeding program that are resistant to diseases such as

- leaf and stem rust
- loose smut
- common bunt
- leaf spots
- red smudge.

Environment and genotype affect characteristics of dietary fiber in rye Environment plays a large effect on dietary fiber, as measured by extract viscosity. A hot, dry filling period increases the extract viscosity (EV), whereas a cool, moist filling period reduces EV. Researchers have found some genotypes that display a stable low EV over all environments. This result indicates that progress can be made by selecting for low-viscosity genotypes for livestock feeding purposes.

Collaborations with US scientists in study on C dynamics Scientists from the Research Branch and the University of Alberta are participating in a cooperative study across the North American great plains. The study, led by scientists at Colorado and Michigan State universities, is designed to quantify and model the effect of crop management on C sequestration in soil. This study, which has so far lasted 4 years, is funded by the US Environmental Protection Agency. It has resulted in

- the publication of a book
- a symposium at the American Society of Agronomists' annual meetings
- a special edition of *Tillage Research Journal*.

Improved dryland alfalfa production Alfalfa grown between windbreaks of tall wheatgrass produced 40% higher yields than alfalfa grown in an open field. This result is attributed to better moisture conservation between the windbreaks. To promote the technology, a local producer organization has set up a field demonstration.

Salinity tolerance The tolerance of crops to chloride salts as determined in the SPARC testing facility was found to be similar to the tolerance to the sulfate salts that predominate on the Canadian prairies.

Ground water protection Using bulk samples of the subsoil to estimate its capability for degradation and sorption of pesticides may greatly underestimate those capabilities. This approach doesn't consider the natural variability of soil. In particular, the walls of the subsoil pores through which the pesticides are moving have much higher organic-matter concentrations and microbiological activities than would be measured in the sample.

International modeling effort SPARC is collaborating with Michigan State University to develop the model SALUS (System Approach to Land Use Sustainability). The model will be derived from both the CERES crop-growth model, and the CENTURY model of soil organic matter and nutrient dynamics. The model is intended to serve a decision-support-system for managers and extension specialists.

Zero tillage enhances carbon sequestration in the soil A 12-year study shows that zero tillage increases the C stored in surface soils. However, the amount of C gained depends on

- differences in the amount of crop residues returned to the land (therefore grain yields)
- amount of soil disturbance
- soil texture (the greater the clay content of the soil the greater the C storage potential of the soil).

This finding has important connotations for the impact of agricultural management on global warming.

Use of fertilizers fosters agricultural sustainability Using soil from a long-term rotation study in east-central Saskatchewan, researchers showed how proper fertilization with N and P, coupled with annual cropping, could maintain or increase yields and improve soil fertility. Further, scientists showed the need to apply P fertilizer to legume-containing crop rotations; otherwise maximum production is not achieved. Also, frequent mechanical tillage is found to be one of the main factors inducing soil degradation.

New alfalfa variety An experimental alfalfa synthetic, designated SC Mf3713, was submitted for variety registration in 1996. This variety, with the proposed name Yellowhead, is a very persistent, yellow-flowered, synthetic that tolerates grazing. The area of adaptation is the Parkland region of the Prairie Provinces.

Shiny plants make better seed Compared with normal green Altai wildrye, waxy Altai wildrye plants produce more seed with better

- quality
- seed weight
- germination.

The differences were consistent for all 3 years of seed production. There was some evidence that seedling emergence was better for the glaucous lines, but this result was inconsistent over time. In one year of three, there was a significant, positive, correlation between the amount of surface wax and seed germination. Maternal characteristics that avoid water stress may be important in improving the performance of seeds and seedlings of grasses for the semiarid prairie region.

Nitrogen-supplying power and fertilizer recommendations On the Canadian prairies, nitrogen fertilizer recommendations are based on mineral N measured in soil before seeding. However, plant-available N produced by the soil during the growing season is not accounted for. A review paper discussed how knowledge of the potentially mineralizable N in a soil can be used together with crop-growth models to improve prediction of N fertilizer requirements.

Nitrogen management for sustainable crop production Scientists have reviewed how N should be managed to ensure sustainable crop production under temperate and tropical conditions. The principles governing the behavior of N in the soil–plant system are similar in all ecosystems; it is the rates of nutrient cycling and the socio-economic constraints that differ. Organic or mineral forms of N inputs, if used responsibly, will

- increase crop production
- provide quality food
- increase net returns
- reduce risk of monetary loss
- improve soil quality
- reduce N loss via leaching and gaseous means.

The key to sustainable management of N is to synchronize N supply with N use by the crop.

Factors affecting carbon storage in soils A 29-year long-term crop rotation experiment is being done at Swift Current. A bulletin summarizes all information available to 1993 regarding factors affecting soil carbon storage, including

- fertilizers
- cropping frequency
- pulses
- oilseeds.

This bulletin has been in great demand by colleagues and libraries throughout North America because it is relevant to global warming.

Crop models and decision-support systems Because agricultural systems are complex, decisions for managing our scarce agricultural resources are seldom optimized. Recent advances in computer technology enable scientists to

- integrate their knowledge
- represent the soil–plant–environment system quantitatively through computer simulation models.

By combining these simulation models with computerized decision support systems, our ability to make optimal management decisions is greatly expanded. Thus sound management decisions can be made for current climatic, environmental, or economic conditions, as well as for anticipated changes in the future.

Soil phosphorus may leach in prairie soils A cooperative project was done, involving the University of Saskatchewan, the Potash and Phosphate Institute of Canada, and NSERC. A graduate student demonstrated that despite the reputed immobility of phosphorus in soils, over the years significant leaching of this nutrient has occurred under prairie conditions. Precipitation regime had no effect on phosphorus leaching. However, land relief seemed to be more important.

Health of Our Soils report Soil degradation risk was assessed in relation to land management for the prairies. Included for the 1981–1991 period are

- maps showing the current wind and water erosion risk
- tables showing the change in erosion risk.

Ecological land classification An ecological land classification framework and database were developed for Saskatchewan. The framework forms part of the national system. A poster map entitled “Ecoregions of Saskatchewan” was published.

Soil inventory of Saskatchewan completed The inventory of the agricultural soils of Saskatchewan has now been completed. All the information will be digitized and soil reports published by the summer of 1997.

Suitability ratings for irrigated potatoes and beans Reports and maps were prepared for seven areas of the province covering approximately 6.9 million hectares along the

- Qu’Appelle Valley
- South Saskatchewan River
- North Saskatchewan River.

About 0.9 million hectares were rated as excellent for irrigated potatoes.

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Mandate

The mandate of the Lethbridge Research Centre is to develop new and improved technology

- to increase the efficiency of beef production and beef quality
- to enhance the competitiveness and sales of Canadian beef in world markets.

The mandate also includes

- development of sustainable and profitable production systems for dry and irrigated cultivated land and rangeland in the southern Canadian prairies
- the transfer of new technology to the agricultural industry.

Resources

Research is conducted at

- the main centre near Lethbridge
- the research ranch at Kamloops
- the field sites at Onefour, Stavely, and Vauxhall.

In addition, the Alberta Land Resources Unit, operating out of Edmonton, reports to the Lethbridge Research Centre. This unit conducts soil classification and land use studies in Alberta.

The main centre is located in the Agriculture Centre, a facility shared with

- the regional office of Alberta Agriculture Food and Rural Development
- Food Production and Inspection Branch of Agriculture and Agri-Food Canada.

It has an immediate land area of 500 ha. It also includes

- a 17 000-ha beef cattle ranch near Manyberries
- a 400-ha ranch near Stavely in the foothills of the Rocky Mountains
- a 130-ha irrigation substation at Vauxhall.

The Kamloops Range Research Ranch has a land base that includes

- 57 ha of irrigated land
- 470 ha of forested rangeland
- several thousand hectares of provincial rangeland.

The staff comprises 279 full-time equivalents, including 75 in the professional categories. The centre operates with a budget of \$18.8 million, including funding for the MII and other special programs. In addition the centre receives more than \$7 million from external sources.

Achievements

- *Staff awards and honors*
- *Canola-based diets for calves*
- *Shear stress test of forage quality*
- *Enzymes boost cattle growth*
- *Effective fiber guidelines*
- *Grain structure and digestion*
- *Methane production in cattle*
- *Lignosulfonate increases bypass protein*
- *Bloat prevention*
- *Toxic plants*
- *Mineral-deficient forages on saline land*
- *Protection from insect pests*
- *Estrus synchronization*
- *Environment for scrotal thermography*
- *Modeling thermoregulation affected by diet*
- *Growth hormone regulation vaccine*
- *Predicting growth potential of lambs*
- *Lamb production*
- *New navy bean cultivar and DNA test for bean blights*
- *Improving alfalfa production*
- *Forage performance at different elevations and on Gray Luvisolic soils*
- *Potatoes: cultivar identification and new storage diseases*
- *Molecular biology education kit developed*
- *Safflower production*
- *Molecular marker for bunt in wheat*
- *Barley genome map*
- *Oil content in canola*
- *Biological control of Canada thistle and purple loosestrife*
- *Control of mallows*
- *Herbicide resistance in wild oats*
- *Leafcutter bees and their pathogens*
- *Grasshopper thermoregulation*
- *Insecticide impact*
- *Pest outbreaks and mapping*
- *Biocontrol of insects*
- *Russian wheat aphid control*
- *Modeling climate change and its impact*
- *Soil moisture model*
- *Evapotranspiration models*
- *Solar radiation modeling*
- *Long-term manure disposal*
- *Rhizosphere of canola and wheat*
- *Earthworms in Alberta*
- *Economics of reduced tillage and conservation farming*
- *Crop residue studies*
- *Soil moisture affected by rotation*
- *Soil erosion evaluations*
- *Soil landscape database and soil surveys*
- *Soil classification*
- *Soil and water quality*

Staff awards and honors The following scientists were honored during the past year:

- Dr. Mark Goettel was awarded a fellowship for Internationally Renowned Senior Foreign Scientists, February - July, 1996, by the French Ministry of National Education, Advanced Education, Research and Professional Placement, Paris.
- Dr. Tim Lysyk was awarded the Entomological Society of Canada's C. Gordon Hewitt Award for outstanding achievement in entomology by an individual under 40.
- Dr. David Major was made a fellow of the Canadian Society of Agronomy.
- Dr. Tim McAllister was awarded the Pfizer Young Scientist Award, given by the Canadian Society of Animal Science, for 1996. This award is presented to an individual who has made a significant contribution to livestock production in Canada within 7 years of completion of their Ph.D. Dr. McAllister received the award 4 years after his Ph.D. was completed.
- Dr. Steve Morgan Jones received the Canadian Society of Animal Science Merit Award. This award is the highest bestowed by the society to recognize outstanding achievement.
- Dr. Wayne Pettapiece was named a fellow of the Agricultural Institute of Canada and is president of the Alberta Institute of Agrologists.
- B.D. Walker is president of the Alberta Chapter of the Soil and Water Conservation Society.

Canola-based diets for calves Offering canola-based diets to nursing beef calves during the later part of the grazing season increased growth rate by 30%. Treating canola meal using heat and lignosulfonate decreased ruminal protein degradability, but treated canola meal would be most cost effective when fed to cattle requiring high levels of undegradable intake protein.

Shear-stress test of forage quality Resistance to shearing was found to be a rapid, reliable, low-cost method of evaluating the physical properties of forages. Shearing-force characteristics determine resistance of the forage to particle-size reduction during mastication, which is the initial rate-limiting step in ruminant intake and digestion of forages. Plant-breeding programs designed to improve the overall nutritive value of a particular forage species could use this technique for selection.

Enzymes boost cattle growth Under the right conditions, feed enzymes can promote large increases in beef cattle

- growth rate
- gain-to-feed ratio.

With increasing consumer concern about the use of growth promoters and antibiotics in animal production, and the magnitude of increased animal performance obtainable using feed enzymes, enzyme technology will no doubt play an important role in future cattle production.

The mode of action of fibrolytic enzyme additives in ruminant diets was reviewed, so that enzyme preparations could be formulated and applied in ruminant diets to produce consistent and optimum responses.

Effective fiber guidelines Guidelines for using forage fiber analysis (determined as acid and neutral detergent fiber) in dairy cattle diet formulation were developed. The fiber content of forages was considered as a predictor of the energy content of feed and dry matter intake of cows.

Grain structure and digestion The structural properties within cereal grains dictate the rate and extent of starch digestion in the rumen. Grain processing techniques have been developed for improving the microbial processes of

- attachment
- penetration
- colonization
- biofilm formation.

Methods have also been developed for manipulating the ruminal microorganisms involved in cereal grain digestion in order to prevent digestive disturbances.

Methane production in cattle The amount of methane produced by ruminal microorganisms as a metabolic end product is affected by numerous factors. These must be considered in developing management strategies to mitigate methane emissions from ruminants without compromising animal production efficiency. Two interventions that may prove effective are

- enhancing the reduction of carbon dioxide to acetate
- direct genetic manipulation of ruminal methanogens.

Lignosulfonate increases bypass protein Lignosulfonate is a nontoxic, reducing sugar-rich by-product of the pulp and paper industry. At 7% (w/w) it substantially increased rumen-undegradable protein in canola meal and in soybean meal, with no adverse effects on digestibility. Lignosulfonate treatment of barley-based diets for lambs did not affect their average daily gain or feed conversion efficiency. On barley-based diets, growing lambs do not appear to require a source of rumen-undegradable protein.

Bloat prevention Poloxalene (Bloat Guard) was completely effective in preventing alfalfa bloat when given intraruminally but Silent Herder, a mineral mix, was only partially effective in one trial.

The incidence of bloat was substantially reduced when cattle were fed alfalfa in the afternoon instead of morning. The risk of bloat is reduced if cattle are turned out to new pastures in the afternoon.

Twenty years of bloat research at Kamloops were summarized, including pasture management procedures to minimize the occurrence of alfalfa bloat.

Condensed tannins are protein-binding compounds present in a number of forages that can reduce the incidence of bloat. These compounds were shown to inhibit the endoglucanase activity of four predominant ruminal fungi, but the fungi were less sensitive to the condensed tannins than are ruminal bacteria.

Toxic plants A total of 45 alkaloids were identified in low larkspur, the major one being neurotoxic to cattle.

Two new aliphatic nitrotoxins with novel esterified groups were isolated from Canada milkvetch, which is very widely distributed in North America.

A survey was done of the hepatotoxic alkaloids in a number of *Senecio* species (ragwort, groundsel and butterweed family) growing on clear-cut logging areas in British Columbia. Results showed that these plants are unlikely to be at risk to grazing livestock, since the alkaloid levels were relatively low, unlike in other parts of North America.

Some ruminal bacteria are able to degrade acutely toxic plant toxins, such as

- the amino acid mimosine (from *Leucaena*)
- the following cyanohydrins:
 - prunasin (from wild cherry and serviceberry)
 - amygdalin (from peach and apple seeds)
 - linamarin (from white clover and cassava).

Transfer of these toxin-degrading bacteria among ruminants may permit expanded grazing in North America and world wide.

Mineral-deficient forages on saline land Forages grown on saline soils are frequently deficient in minerals required by beef cattle for adequate nutrition. When reclaiming saline areas by growing salt-tolerant forages, producers should have these feeds analyzed and diets adjusted accordingly.

Protection from insect pests The role of antibodies in the protection of the howler monkey from infestation with the monkey bot, *Alouattamyia baeri*, was examined. The work was part of the studies developing vaccines against specific insect pests of livestock. The response of monkeys to first-instar antigen was found to be directly correlated to infestation levels.

An image analysis method was developed for quantifying fluctuating asymmetry of wing characters in horn flies. The image analysis method provides measurements that are objective, precise, and repeatable.

Estrus synchronization Estrus was synchronized in cattle by feeding melengestrol acetate for 7 days and giving estradiol on the first day and prostaglandin on the last day. This technique is a simple, cost-effective method of synchronizing estrus in cattle.

Environment for scrotal thermography Infrared thermography for assessment of scrotal surface temperature in bulls can be performed at any time of the day, except within several hours after feeding or within 1 h of rising. The scrotum should be dry and the measurements can be taken over a wide range of ambient temperatures, although abrupt changes in ambient temperatures may result in artifacts due to overcompensation.

Ejaculation (either spontaneous or electroejaculation) increased the temperature of the cauda epididymides, resulting in a localized increase in scrotal surface temperature. Therefore, infrared thermography for assessment of scrotal surface temperature in bulls should be conducted before ejaculation or semen collection.

Modeling thermoregulation affected by diet Insulating only the neck of the scrotum significantly increased both intratesticular and scrotal subcutaneous temperatures; scrotal surface temperatures initially increased and then returned to pre-insulation levels, apparently as a result of compensation. This model illustrates the effects of excessive dietary energy that results in considerable fat deposition in the neck of the scrotum, producing

- high scrotal temperatures
- low fertility.

Growth hormone regulation vaccine Freund's Complete Adjuvant was superior to Havlogen and Alhydrogel, two adjuvants commonly used in vaccines, for the production of somatostatin (SRIF) antibodies in calves. However, despite developing SRIF antibodies, immunized calves did not grow faster.

Predicting growth potential of lambs Plasma IGF-1 concentrations obtained in lambs as young as 7 weeks of age were positively correlated with their rate of gain to slaughter weight. This work is the first time that plasma IGF-1 has been shown to indicate growth potential in ruminants.

Lamb production Ultrasound measurement of fat depth at the first lumbar vertebrae was a good predictor of saleable meat yield in lambs. However, ultrasound was less useful as a predictor of subjective conformation score as determined in the Canadian Classification System for lamb.

Induction of parturition with a combination of dexamethasone and cloprostenol was no more effective than dexamethasone alone and in fact resulted in greater variability in the time of lambing. Dexamethasone alone effectively induced lambing with excellent fetal viability and no maternal complications.

Sweet lupin seed is comparable to soybean meal and canola meal as a protein supplement for lambs. Lupin seed has potential as a home-grown protein supplement with no processing required.

New navy bean cultivar and DNA test for bean blights A navy bean was registered as AC Skipper, which offers

- early maturity
- good canning characteristics (no matting in cans)
- good yields in narrow rows.

Growing beans in solid stands to reduce input costs becomes feasible with this new cultivar.

Polymerase chain reaction primers were developed, enabling amplification of specific DNA fragments diagnostic of the causal agents of

- halo blight
- common bacterial blight.

These primers can be used to simultaneously detect both diseases.

Improving alfalfa production The annual economic benefit of growing verticillium-resistant cultivars of alfalfa over those with low resistance was \$44 a hectare in areas where verticillium wilt is present. This improvement represents a potential benefit to producers in western Canada of \$2.2 million a year. Growing regionally adapted alfalfa cultivars in western Canada would return \$27 million a year more than cultivars not developed for this area.

In the interior regions of British Columbia, seeding rate for maximum yields of alfalfa were

- 16.8 kg/ha (15 lb/acre) in the seeding-year under irrigation
- 5.6–12.4 kg/ha (5–11 lb/acre) in the first full-production year under irrigation
- 4.5–9.0 kg/ha (4–8 lb/acre) on dryland sites.

Higher seeding rates are required under irrigation to obtain maximum seeding-year yields, and to allow for the greater plant death rate that occurs.

On acid soils, without liming, alfalfa required seed preinoculation for effective nodulation, whereas alsike clover and red clover did not. The combination of lime and preinoculation increased alfalfa dry matter yield by 136% and crude protein level from 9.2 to 15.4%. Addition of lime alone increased alfalfa dry matter yield by an average of 130% and crude protein level from 9.2 to 16.3%. With preinoculation alone, alfalfa dry matter yield increased by 100% and crude protein level increased from 9.2 to 12.7%.

Forage performance at different elevations and on Gray Luvisolic soils Yield and quality data were obtained for growth of eight grasses and five legume species at two sites in the British Columbian interior, differing considerably in elevation. Alfalfa out-yielded all other species at both sites. Alfalfa yield was better distributed throughout the growing season than that of the other legume species. Nutritional quality of all species was similar.

Forages improve the nitrogen-supplying power of Gray Luvisolic soils, and forage mixtures that include legumes have the greatest potential.

Potatoes: cultivar identification and new storage diseases Researchers identified 41 different simple sequence repeats within the 262 reported *Solanum* cDNA sequences. These sequences were shown to be ideal for cultivar identification. This technique is now being used to distinguish potato cultivars.

A new problem in potato storage was discovered. The incidence of resistance to the benzimidazole fungicides in *Fusarium* species and *Helminthosporium solani* was determined and this disease resistance was shown to be responsible for increasing storage losses.

Molecular biology education kit developed In cooperation with Alberta Agriculture, Food and Rural Development, an educational facilitator's guide for agricultural biotechnology was produced. It includes

- a book of exercises
- video
- computer software
- CD disk.

This multimedia kit entitled *A Quick Dip in the Gene Pool*, is being distributed to over 2000 high schools in British Columbia, Alberta, Saskatchewan, and Manitoba.

Safflower production AC Sunset safflower was registered. It has

- the early maturity and sclerotinia resistance of Saffire
- higher yield and oil levels than AC Stirling.

With its shiny white seed coat, AC Sunset is an attractive dual-purpose safflower well-suited to the birdseed market. It has some potential as an oilseed.

Several bacterial species showed promise as agents for biological control of damping off of seedling safflower.

Local environmental factors significantly influence safflower traits, including

- seed yield
- percentage of oil
- days to maturity
- test weight.

Potential cultivars need to be evaluated at as many locations as resources permit.

Commissioned by the International Plant Genetics Resources Institute (in Rome), contributions were made to a compendium of handbooks, references, addresses of institutions, and scientists involved in

- safflower research
- storing safflower genetic resources
- other under-utilized and neglected crops.

Scientists can use this information to make direct contacts for obtaining germplasm accessions.

Molecular marker for bunt in wheat A DNA marker linked to the bunt Bt10 resistance gene in wheat was identified and characterized. The marker was present in all resistant lines and absent in all susceptible lines tested. This marker is now in use in the western Canada wheat-breeding program.

Barley genome map As part of a review of barley genome mapping, scientists presented

- the most current barley map of a cross between Harrington and Tr306
- the implication of the genetic map on barley and cereal research.

Oil content in canola DNA sequences that have potential of increasing oil content in canola seeds were isolated, using the differential display method.

Biological control of Canada thistle and purple loosestrife An image analysis method was developed to measure feeding damage caused by leaf beetle species on Canada thistle. The method can be used to evaluate efficacy of biocontrol insects and host specificity of biocontrol agents.

Comparisons were made of the biology, morphology, and DNA banding patterns of the Canada thistle beetles

- *Altica carduorum*
- *A. cirsicola*.

Results revealed that they are different species, and hence should undergo separate host specificity testing. The technology developed from these morphologic and genetic analyses enable an accurate and rapid identification of the two species.

Purple loosestrife biocontrol agents in North America can be successfully established regardless of method or location of insect release.

Control of mallows The infection mode of *Colletotrichum gloeosporioides* f. sp. *malvae* was discovered and related to why this fungus is highly pathogenic on some mallow weeds, but not others (*Malva negelect* and *Abutilon theophrasti*). The finding will assist in biological control of mallows.

Stork's-bill and round-leaved mallow both emerge at cool soil temperatures (10–15°C) and are therefore competitive weeds in early-planted spring crops. Vegetative production and competitive ability were greatest at a mean daily

temperature of

- 17°C for stork's-bill
- 20°C for round-leaved mallow.

Crop rotation sequences including late-seeded spring crops or winter cereals should be useful in managing these increasingly troublesome weeds.

Herbicide resistance in wild oats Triallate-resistant wild oat populations were not controlled by difenzoquat but were controlled by

- atrazine
- ethalflurlain
- fenoxaprop-P
- flampop
- imazamethabenz
- tralkoxydim.

Leafcutter bees and their pathogens Paraformaldehyde at currently registered rates was found to effectively kill chalkbrood spores (*Ascosphaera aggregata*) on the leaf pieces forming bee cells. However, dose and treatment times must be increased significantly to kill spores within cadavers of infested leafcutter bees.

A new species of fungus causing disease in alfalfa leafcutting bees was described.

Grasshopper thermoregulation Researchers determined

- the rate of increase in insect body temperature caused by exposure to sunlight
- how the rate is affected by body orientation.

Behavioral responses in nymphal grasshoppers result in body temperatures of 40°C, which is near the optima for both feeding and development.

Insecticide impact Three grasshopper insecticides did not cause significant mortalities of pheasants fed treated grasshoppers or caged on sprayed range grass. However, the treatments resulted in depressed brain enzyme activity, and all three insecticides differed in the degree of impact.

The degree of detoxification ability in the laboratory strain of the migratory grasshopper appears to be much higher than in related species, including the wild strain of the same species. This result calls into question the use of the laboratory strain of the migratory grasshopper for toxicological and efficacy testing.

Pest outbreaks and mapping Space - time analysis of long-term infestation data indicates that outbreaks of insect pests behave differently in different ecozones, and that outbreaks differ in the quality of this interaction from year to year.

The development and application of methods from the Geographical Information System for insect forecasting in Alberta, 1987–1992, were reviewed.

Biocontrol of insects Because of their selectivity and minimal environmental impact, microbial control agents will be ideal components of integrated pest management programs in the early 21st century and beyond. However, if these agents are used merely as replacements for chemical pesticides, then eventually these agents will face the same fate as the chemicals they replace, particularly with respect to resistance.

Fungi are among the most important microbial pathogens of grasshoppers for use as biological control agents. Field trials in Africa and North America have demonstrated significant grasshopper reductions. Improvements in formulation and inoculum targeting may further improve their efficacy.

The formulation of the fungal pathogen *Beauveria bassiana* in oil was found to significantly improve efficacy by facilitating the distribution of spores on the host insect. Grasshoppers, basking in sunlight for as little as 1 hour a day

and thereby raising their body temperatures, were able to overcome infection by *Beauveria bassiana*. From 28 to 61% of conidia could be washed off by rain immediately after application. This would reduce the effectiveness of *Beauveria* treatments. The addition of UV protectants to formulations of *Beauveria bassiana* were found to provide some protection to the control agent against UV radiation.

Russian wheat aphid control Control of Russian wheat aphid with chlorpyrifos was improved when

- crops were sprayed at the two-leaf rather than the three-leave stage
- a nozzle angle of 45° pointed ahead was used.

No effect on control was achieved by

- post-spray temperatures
- amount of leaf curl
- spray volume.

These results help explain acceptable control with lower rates of insecticide previously observed.

Modeling climate change and its impact The validity of the Palmer Drought index for characterizing drought on the Canadian prairies was assessed. The drought index obtained by improvements in the soil water simulation explained 49% of the variation in wheat yield, compared with 33% explained by the original Palmer index.

A study was conducted on the effect of a change in climate on regional aspects of drought frequency and duration and other agro-climatic indices in the province of Alberta. The results suggest that where climate change is based on increases in both precipitation and temperature, drought frequency and persistence (measured by a modified Palmer Drought Index) will decrease across Alberta.

Soil moisture model A model which accounts for the major components of the hydrological cycle to simulate soil moisture content for drought monitoring and crop yield prediction was modified. The soil moisture simulated by the modified model compares better with measured values than that simulated using the original version.

Soil moisture controls many important processes in the soil - plant system, including

- seedling emergence
- evapotranspiration
- mineralization of the soil organic fraction
- surface runoff
- leaching
- crop yield.

Researchers reviewed direct applications of soil moisture models in agronomy

- from the field to regional scale
- for daily to seasonal time steps.

Evapotranspiration models Several common models of potential evapotranspiration were compared against pan evaporation measurements for daily and weekly time intervals at two semiarid sites:

- Lethbridge, Alberta, Canada
- Hengshui, Hebei Province, China.

Commercially available water-level sensing transducers mounted on class A pans were compared with manual measurements. Hourly measurements for free-water evaporation allowed examination of the correlation between principal weather elements and evaporation.

Solar radiation modeling Several regional equations were compared for calculating global solar radiation on the Canadian prairies. Estimates were best derived from spatially interpolated bright sunshine duration than from locally observed air temperature range or precipitation status.

Long-term manure disposal The long-term fate of nitrogen from large annual feedlot manure applications was determined. In rainfed conditions, the nitrogen in excess of crop needs accumulated in the soil, but on irrigated land, appreciable amounts of the nitrogen leached into the groundwater and some was lost to volatilization.

New approaches to the estimation of phosphorus (P) fractions are needed to understand P dynamics in soil used for manure disposal. Phosphorus levels are building to extremely high levels in some soils used repeatedly for manure disposal.

Long-term manure applications increased the cation exchange capacity of soil by increasing total organic carbon. As the amount of manure in annual applications increased, the percentage of sand in the receiving soil also diminished.

Scientists tabulated

- information on cattle and feedlots by region
- potential manure production in the southern interior of British Columbia.

Details of activities related to the livestock industry in the interior of British Columbia will be used to prevent pollution and minimize waste.

Rhizosphere of canola and wheat Canola and wheat were found to utilize different mechanisms to influence their root rhizospheres and obtain their nutritional requirements. Rhizosphere changes were a function of

- plant species
- soil type
- previous soil management history.

Earthworms in Alberta An updated species distribution for the province of Alberta was documented with a description of a new earthworm species native to Canada, *Apporectodea bowcrowensis* n.sp. (Lumbricidae).

Economics of reduced tillage and conservation farming The economic returns from reduced tillage fallow systems are at least equal to those from conventional tillage. However, if perennial weeds are present that are difficult to control with herbicides but easy to control with tillage, the returns from systems with tillage will be higher than from those without tillage. A primary factor in the profitability of reduced tillage fallow systems is for the reduced tillage system to be low cost (low herbicide costs) because the reduced tillage system is replacing a low-cost tillage system.

A collection of 52 factsheets on conservation farming and results of activities from the Parkland Agriculture Research Initiative was prepared and is available.

Crop residue studies Natural crop residue losses during fallow were highest with lentil, followed by

- canola
- rye
- barley
- wheat
- flax.

Three applications of glyphosate, paraquat, or 2,4-D at recommended rates did not alter field degradation of any of these crops. Weed control by herbicides maintained greater amounts of anchored and total surface crop residues for erosion protection than wide-blade tillage.

A distinction must be made between above- and below-ground crop residues: their roles are distinctly different in maintaining soil organic matter. Above-ground crop residue protects the soil and creates the conditions for below-ground residue to decompose and transform. These decomposition products, in turn, create favorable soil structure for plant growth. Aggregate stabilities of crop-residue-amended soils were significantly higher than those soils treated with animal manures or inorganic fertilizers.

Soil moisture affected by rotation Averaged over 10 years (1985–94), available water for establishment of winter wheat in the fall was least after canola (45 mm), followed by

- continuous winter wheat (59 mm)
- lentils or flax (74 mm)
- fallow (137 mm).

In this semiarid region (Lethbridge, Alberta), the effect of rotation on soil water regime is much greater than the effect of tillage system.

Soil erosion evaluations Removal of 10 cm of topsoil reduced nonfertilized production by 43–66% as compared with undisturbed nonfertilized soil. Removal of 20 cm of topsoil reduced nonfertilized production by 60–85%. Additions of N and P fertilizer only partly remedied these losses. Responses to N and P were highest at moderate levels of erosion.

In contrast to results from the literature describing soil erosion in hummocky moraine in central Alberta, the greatest soil loss for 1995 and 1996 occurred on slope crests, with much less of a soil loss from upper- and mid-slope positions.

In 1996, the first year of snowmelt measurements in hummocky moraine, greater soil loss (80 g/m² in two events) was recorded on the south-facing slope and less soil loss (12 g/m² in one event) on the north-facing slope. Run-off from the north slope showed the presence of applied herbicide, whereas none was detected in the run-off from the south-facing slope.

As part of the National Agri-Environmental Indicator Project, changes in erosion risk from 1981 to 1991 were evaluated in Alberta. About 13% less erosion risk was seen in 1991 than in 1981. About 5% of the reduction resulted from changes in cropping practices and 8% from changes in tillage practices.

Two of Alberta's four landuse - soil quality benchmark sites were resampled, continuing the effort to monitor agricultural soil quality to determine the effect of 80 years of cultivation. Net soil erosion rates ranging from 1.9 kg/m² a year on hill crests to -4.3 kg/m² in depressions were calculated using ¹³⁷Cs data. Surface organic carbon losses were attributed mainly to erosion plus tillage dilution across hilltops, and to mineralization alone on lower slopes and depressions. Significant differences were found from hilltops to depressions in

- pH
- organic C content
- available K
- other attributes.

The work holds some important implications for precision management.

Soil landscape database and soil surveys A standardized digital soil landscape database has been compiled in cooperation with Alberta Agriculture, Food and Rural Development through contracts with private soil consultants, for 1800 townships of a total 2700 townships within the agricultural portion of Alberta.

The soil surveys of the Gleichen SE and SW map sheets were completed and presented at a moderate level of detail in generalized report and map form.

Soil classification Clay textured soils across Canada have been systematically examined over the last few years. Based upon these findings a Vertisolic soil order has been included in the Canadian System of Soil Classification.

A soil landscape model was developed

- to automatically describe landforms using computer-interpolated contour lines
- to allocate soils to defined landform segments.

A procedure was developed to provide standard regional descriptions of crop rotations in Alberta based on Census of Agriculture data. An assessment for 1991 was completed.

A (d-base) program was developed for the automated calculation of Land Suitability Ratings for spring-seeded small grains using standard national and provincial soil survey data files.

Soil and water quality Measurement of soil quality was accomplished by removing topsoil from a plot and replacing it with 36 other soils having varied characteristics. Biomass production responded to differences in soil characteristics and served as a relative measure of soil quality.

The following herbicides were found to leach into shallow groundwater under certain conditions in southern Alberta:

- bromoxynil
- 2,4-D
- diclofop
- MCPA
- triallate.

The highest levels, some exceeding the Canadian drinking water guidelines, occurred when the first moisture event after a herbicide application was a heavy rainfall or irrigation.

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- *** Alberta-Canada Barley Agreement, Lacombe Research Centre

Mandate

The Lacombe Research Centre has a national mandate to conduct research on the ante- and post-mortem factors of red meats that influence

- yield
- quality
- safety
- preservation.

With its affiliated sites and research partners, the centre develops integrated, sustainable crop and animal production systems and crop varieties for the short-season environments of the Parkland and northwestern Canada.

Resources

The Lacombe Research Centre manages a total operating budget of \$8.4 million, including about \$2.4 million in industry investment and Matching Investment Initiative funding. In 1996-97 it had a complement of 114 full-time equivalents at the Lacombe and Beaverlodge sites, including 34 professionals.

The lead centre is located in Lacombe between Edmonton and Calgary on 808 ha of land, which has facilities for raising beef cattle and hogs. At Lacombe facilities include

- a holding barn, abattoir, blast chiller, coolers, cutting room, taste panel kitchen, and sensory analysis booths
- greenhouse, plant growth chambers, dryers, threshers, and seed storage
- laboratories
- offices.

Affiliated with Lacombe are the Beaverlodge Research Farm (BRF) and the Fort Vermilion Field Site. BRF controls 390 ha of land at two sites and rents about 35 ha of land a year for research. The Fort Vermilion field site owns 187 ha of land and rents about 3 ha of land for research. Operation is on a growing season basis only.

The centre has advisory committees reflecting research conducted at the centre. Committee members comprise leaders from

- industry
- government
- universities
- commodity groups
- the farming community.

The centre supplements its resources with research and in-kind grants from provincial governments, producer groups, and agri-business. It is active in the release of plant varieties and the commercialization of technologies developed through their research.

Achievements

- *Centralized production of ground beef*
- *Expert computer vision system for detecting stressed cattle*
- *Computer vision beef grading system*
- *Consumer acceptance of beef*
- *Ractopamine use*
- *On-line altered suspension of beef carcasses*
- *Single-limb infusion model*
- *Porcine somatotropin improves carcass characteristics*
- *Stress susceptibility and pork quality*
- *Pork quality from a digitized image*
- *Supplementing feedlot diets with rumen-protected amino acid (RPAA)*
- *Carcass and meat quality of farmed whitetail deer*
- *Western forage-beef group*
- *Nutrient cycling*
- *Forage grass seed production*
- *AC Sunbeam canola*
- *Pest control in honey bees*
- *Legume inoculants*
- *Soil microbial diversity*
- *Weeds in legume-based cropping systems*
- *Conservation tillage and plant diseases*
- *Inoculation and field pea yield stability*

Centralized production of ground beef Centralized production of coarse ground beef was evaluated at a major meat-packing plant, in cooperation with the University of Alberta. Centrally produced ground beef distributed in vacuum and stored for up to 20 days can still have a retail case life of 2 days. Centralized retail meat production systems afford the industry these benefits:

- product of more consistent quality
- improved safety and storage life
- reduced packaging materials
- reduced labor at the retail level.

Expert computer vision system for detecting stressed cattle A US patent recently issued to the Lacombe Research Centre describes an invention to predict meat quality from infra-red images on live animals before slaughter. Infra-red images taken of cattle or pigs in loading chutes are instantaneously analyzed with a microcomputer. Animals identified as being predisposed to producing poor-quality meat can then be rested, fed, and restored to a normal physiological condition before slaughter. This real-time computer vision system can identify with great accuracy the dark cutting condition in beef in the live animal. Without this detection system, producers face discount of \$250 per carcass.

Computer vision beef grading system The Lacombe Research Centre recently developed, with the Canadian Meat Council and the Canadian Cattlemen's Association, a prototype computer vision system to grade beef carcasses in real time. Both the hardware and software components were engineered. This prototype has been tested in one beef packing plant in Alberta. A commercial unit should be engineered and installed early in 1997.

The system consists of two subsystems.

- The hot carcass imaging system digitizes an image of the whole left side and makes a series of measurements contributing additional information for predicting carcass value.
- The cold carcass imaging system records an image of the ribeye and performs measurements on fat depth, area, meat color, and marbling.

Consumer acceptance of beef Per capita consumption of beef has declined. Recent consumer surveys show a majority of Canadian consumers believe the eating quality of beef has deteriorated during the past decade. Many consumers attribute this deterioration to increased toughness and indicate they have altered their purchasing and consumption practices. Considerable controversy has existed over the past five decades regarding the degree of fatness required to assume acceptable beef cooking quality. A recent Lacombe study demonstrated that 8 mm of subcutaneous fat and a small degree of marbling provides 90% consumer acceptability based upon eating satisfaction.

Ractopamine use Past studies have established that ractopamine, a beta-agonist, incorporated into the finishing diets of swine, improves growth performance and carcass yield. A recent Lacombe study confirmed ractopamine use reduces carcass lipids without influencing the eating quality of cured and smoked pork products.

On-line altered suspension of beef carcasses Traditional processing of beef carcasses allows considerable rigor shortening in the loin and major muscles of the hind limb. Rigor-related toughening can be reduced by simple alterations to the hanging carcass that result in

- decreased shear force values of 1.1–2.3 kg
- reduction of unacceptable scores for overall tenderness from 19.2–2.5%
- improved overall palatability scores.

The procedure holds promise for commercial abattoir use to improve tenderness and acceptability of the major steak muscles from beef carcasses.

Single-limb infusion model A model system was developed in both beef and pork to study cellular-associated changes in tenderness and calcium metabolism. The research technique uses one limb as a control and the paired limb as the test medium. The control so obtained within the animal reduces the error associated with comparisons between animals.

Porcine somatotropin improves carcass characteristics Daily administration of 3 mg of porcine somatotropin resulted in an 18.5% increase in carcass lean and a 27% decrease in carcass fat. Barrows responded more favorably to this treatment than gilts. Porcine somatotropin had no detrimental effects on meat quality. Barriers to the use of this exogenous repartitioning agent include regulatory approval and consumer perception.

Stress susceptibility and pork quality A survey of Alberta commercial pigs indicates that approximately 10% of pigs carry a genetic defect that confers stress susceptibility. These pigs are about twice as likely to produce soft watery pork as are noncarriers of the defect. Removal of the defect from the population would result in only a small decrease in the frequency of soft watery pork. However, its intentional use, in an attempt to gain a small increase in lean yield, would lead to a very undesirable deterioration in pork quality.

Pork quality from a digitized image Digitized image analysis was evaluated for its ability to segregate pork muscles into quality groups based on

- surface color
- marbling content.

Image traits predicted subjective color and structure categories with error rates of 15%, and distinguished pale from normal pork with high accuracy. Image traits were less effective at segregating marbling into its subjectively determined categories, but this was attributed to deficiencies in the subjective scoring of marbling. Although the

evaluation of pork quality from a digitized image requires further refinement, this approach does appear to offer potential for automated evaluation of pork quality.

Supplementing feedlot diets with rumen-protected amino acid (RPAA) Supplementing the basal diets of feedlot cattle with rumen-protected methionine and lysine improved average daily gains in the first 28 days of two feeding trials. Overall, however, feeding RPAA to feedlot cattle for approximately 200 days did not improve their performance. There was a tendency for lean-to-bone ratios to increase, but this observation was not significant and meat quality was unaffected by treatment in both trials. Sex had a larger influence on feedlot performance than did dietary supplementation with RPAA. Heifers tended to respond more positively to supplementation than steers.

Carcass and meat quality of farmed whitetail deer Warm-carcass yields of 35 whitetail deer ranged widely from 51.1% to 67.8%. Dissected lean averaged 72.9% of the carcass, and readily dissectable fat ranged as low as 2.0%. Very high shear values were obtained from the rib eye muscle of conventionally chilled (12°C) sides. Conditioning carcass sides at 10°C for the first 48 h post-mortem reduced shear values

- in the rib eye by an average of 50%
- in the inside round muscle by an average of 25%.

However, large weight losses (7.4%) were sustained caused by dehydration of the carcass sides. High-voltage stimulation of carcass sides applied at 45-min post-mortem had no effect on shear values of the rib eye or inside round.

Western forage–beef group An agreement between Agriculture and Agri-Food Canada and Alberta Agriculture, Food and Rural Development, created a multi-disciplinary core of scientists and extension specialists at the Lacombe Research Centre in May 1996. The group integrates beef herd and forage management research with technology transfer, primarily for the Parkland vegetation zone of western Canada. The group's mandate is to improve profitability and sustainability of the forage-based beef industry. Current objectives are to

- reduce the cost of forage and beef production
- maximize profit per hectare using forage–beef systems
- develop beef production systems that produce high quality meat
- develop sustainable forage–beef systems
- maintain a forage–beef centre of excellence for research and rapid transfer of information.

Nutrient cycling A new program has been established to

- optimize the use of crop residues, including roots and rhizo-deposits
- conserve soil organic matter
- utilize and recycle plant nutrients within soil–plant systems efficiently.

Forage grass seed production Focus on improving methods of grass seed production for the forage seed industry has determined

- optimum row and plant spacing for red and tall fescue
- that tall fescue does not tolerate the presence of a companion crop
- that tall fescue is a viable cash crop in the Peace River region providing new opportunities and increased diversification.

AC Sunbeam canola A new canola variety, AC Sunbeam, has been released from the canola breeding program of the Northern Soil and Plant Research Unit. This variety is a direct replacement for the earlier released AC Sunshine. It is a short, early maturing variety having improved resistance to white rust. It has the lowest glucosinolate levels of currently released *Brassica rapa* varieties.

Pest control in honey bees Long-term effects of registered chemicals for tracheal and *Varroa* mites on honey bee colonies and honey purity were studied. Formic acid, Apistan, and menthol are safe for use within current tolerance levels. Additionally, a laboratory kit for detecting tracheal mites in honey bees was developed.

Legume inoculants Rotations including field peas (*Pisum sativum* L.) are important for sustainable agriculture on acid soils in northwestern Canada. Experiments were done to assess the effectiveness of three principle forms of inoculant at various soil pHs. Granular and powdered peat inoculants increased

- nodule numbers and weight
- plant nitrogen content
- percentage nitrogen derived from the atmosphere
- total biomass in peas.

Only granular inoculant was effective in establishing nodules at soil pH 4.4. All three formulations were effective at pH 6.6. Granular inoculant has potential for effective nodulation of field pea grown on acid soil.

Soil microbial diversity Reduced or zero-tillage systems increase the soil's microbial diversity. The use of legumes in conjunction with reduced tillage may also contribute to an increase in microbial diversity. Microbial diversity

- benefits long-term sustainability
- increases the resilience of these soils under adverse conditions.

Weeds in legume-based cropping systems Weed populations in 4-year rotation cycles that included wheat, canola, and field peas were generally higher under conventional tillage in years where seedbed moisture was good to excellent and lower under conventional tillage when seedbed moisture conditions were dry. Weed population shifts were not apparent, except that quack grass increased under conventional tillage.

Conservation tillage and plant diseases The following observations were made in tillage studies that included barley, canola, and field peas in rotations:

- the incidence of brown girdling root rot (BGRR) did not increase as surface crop residues increased in a barley–canola rotation
- the level of BGRR in canola was reduced as nitrogen fertilizer rates increased
- scald and net blotch were more apparent when barley was direct seeded or grown with minimum tillage
- blackleg spores declined rapidly under direct seeding systems where barley was followed by field peas.

Inoculation and field pea yield stability Ensuring that the pea plant fixes nitrogen increases yield stability considerably. The application of granular soil inoculant increased field pea yield 10–144%. Pea yields were similar under granular inoculant rates that ranged from 2.8 kg/ha to 11.2 kg/ha. Inoculant placement, either banded to the side and below the seed, applied with the seed, or spread around the seed, did not affect pea yield. Mixing granular inoculant with phosphate fertilizer inhibited pea nodulation.

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Mandate

PARC conducts research on

- horticultural and field crop production and protection, including tree fruits, small fruits, greenhouse vegetables, special crops, and forages
- advanced processing, utilization, and quality of plant products
- the cellular and molecular biology of plant pathogens of significance to agricultural crops
- soil resource conservation and land evaluation
- poultry production.

Resources

PARC (Summerland) in the Okanagan Valley has a modern office and laboratory complex complete with pilot plant facilities for food research. It has a land base of 320 ha, of which approximately 90 ha are irrigated and available for tree fruit and viticulture research. Current plans are to complete in 1997 a \$2.9 million renovation and retrofit of the office–laboratory building and a \$2.5 million construction and renovation of greenhouse space.

PARC (Agassiz) in the Fraser Valley operates two field sites at Agassiz covering 665 ha and two at Abbotsford covering 16.5 ha. It has modern facilities for conducting poultry and greenhouse vegetable research. Current plans are to construct a modern \$17 million office, laboratory, and greenhouse complex by 1999.

The Land Resources Unit is housed with the British Columbia Ministry of Agriculture, Fisheries and Food in Cloverdale, B.C.

The Yukon Land Resources Unit is housed with the Yukon Department of Renewable Resources in Whitehorse.

In 1996–97 PARC's FTE complement is 171, including 53 scientists and other professionals. Its total operating budget is approximately \$12.7 million, including about \$1.5 million of Matching Investment Initiative funds which are supplemented by at least \$1.5 million of industry funds.

Achievements

- *Dairy supplement method evaluated*
- *Poultry cage design awarded*
- *Feeding value of wheat for poultry studied*
- *Compilation of spatial framework of ecozones and ecoregions published*
- *Erosion-trend analysis completed*
- *Tomato practices confirmed*
- *Insect temperature theory published*
- *Spider mite control advanced*
- *Blackheaded fireworm mating-disruption system field tested*
- *Obliquebanded leafroller program developed*
- *Inexpensive biological control identified for raspberries*
- *Monitoring methods assessed for root maggot*
- *Trapping device for Colorado potato beetle*
- *Trap crop method developed for wireworm control*
- *Apple orchard irrigation systems compared*
- *Apple pigmentation augmented*
- *Neem oil identified as biological control*
- *Flaxseed gum substituted as flour improver*
- *Four new anthocyanins isolated from bulbs of red onions*
- *Anthocyanin pigments extracted from purple sunflower hulls*
- *Bag types evaluated for modified-atmosphere-packaging (MAP)*
- *Apple juice clarified*
- *Oxidase enzymes identified in haze formation in fruit juices*
- *Yield and quality of juice enhanced*
- *Sensory methodology applied and developed*
- *Cellulose secretion discovered in recently isolated bacterial strain*
- *Disinfectant treatment for vegetable sprouts*
- *Horseradish oil revealed as powerful antimicrobial*
- *Cold pasteurization of fruit juices studied*
- *Cherry cultivars characterized*
- *Carrot-blanching effects studied*
- *Fumigation prevents disease growth*
- *Antibiotic from apples identified*
- *Powdery mildew identified on ginseng*
- *Endogenous antioxidant capacity increased in broccoli*
- *Apple rootstock trials completed*
- *Apple tree shape affects orchard design*
- *Apple catalog distributed*
- *Movement of tomato mosaic virus studied*
- *Flavonoids as antiviral compounds*
- *Proteolytic cleavage in tomato ringspot virus studied*
- *Nitrate assumptions proven incorrect*
- *Heavy metal levels studied*
- *Soil test analyses interpreted*
- *Soil tests rejected for fertilizer recommendations*
- *Organic-based fertilizers developed*
- *Poultry ammonia emissions decreased*

Dairy supplement method evaluated A computer-monitored system was developed to record the daily individual intakes of molasses blocks or mineral mixes by groups of grazing cattle. Results of a study using the system indicated

that the supplements were consumed by almost all animals, but that there was considerable variation among animals in the quantity of supplement consumed. Molasses lick blocks would therefore not be a reliable carrier of medication for grazing animals.

Poultry cage design awarded Poultry cages designed to meet standards for bird welfare and concerns for conducting valid experiments were awarded special notice by the Canadian Council of Animal Care for their bird friendliness.

Feeding value of wheat for poultry studied A 2-year study on feeding value of various cultivars of wheat grown at different locations has been completed. Bioassay data indicated that feeding value of grains was dependent on

- cultivar
- environment (growing location and crop year).

Of interest to feeders and grain handlers is that Durum wheats (used for pasta) had significantly higher feeding value than Hard Red Spring or Canadian Prairie Spring wheat cultivars.

Compilation of spatial framework of ecozones and ecoregions published Contributions were made to *A national ecological framework for Canada*, published in 1995. This work provides a comprehensive set of generalized ecological units for monitoring and reporting on the environment in Canada. The compiled spatial framework of ecozones and ecoregions was honored as the top federal government project for 1995 by the Canadian Council of Ecological Areas. The framework was set into legislation as part of the Canadian Environmental Assessment Act, to be used as the geographic basis for documenting environmental impact assessments. It has also been incorporated into a North American ecological areas map prepared for the NAFTA Commission for Environmental Cooperation to monitor sector performances in each member country. It was compiled as a 3-year joint project between Agriculture and Agri-Food Canada and Environment Canada, in collaboration with relevant provincial and territorial government agencies.

Erosion-trend analysis completed A trend analysis for erosion in British Columbia, linking soil landscape polygons with Statistics Canada Farm Census information, showed that between 1981 and 1991 water erosion risk was reduced by 9% as a result of

- reduction in cropland areas
- shifts in the type of crops grown and implementation of conservation tillage
- no-till practices.

This analysis also indicates what regions in British Columbia would benefit most from targeting conservation and erosion control practices to lower the actual erosion risk.

Tomato practices confirmed The influence of storage temperature on flavor of fresh market tomatoes was studied. Ten volatile compounds were collected and analyzed as estimates of tomato flavor. Tomato volatile formation is closely related to fruit coloration; this correlation is complicated by storage temperatures. Current commercial practice is justified in harvesting tomatoes when they are just starting to show color and subsequently handling them at 10–13°C until they are used.

Insect temperature theory published Temperature is a key factor affecting the life-history traits of all insects. A theory that invokes two selection pressures to explain five puzzling effects of temperature on insects was published in 1996. Understanding the forces that drive life-history traits in certain directions is essential for developing consistent and realistic pest-control strategies.

Spider mite control advanced A 5-year project on the development of new natural enemies for biological control of twospotted spider mites neared conclusion this year. A new predator, *Feltiella acarisuga*, is now being commercially reared by a British Columbia company and sold throughout the world for use in greenhouse and field crops.

Another advance in biological control of spider mites is the development of tomato-adapted strains of the mite predator *Phytoseiulus persimilis*. Researchers identified a strain of this predator with behavioral and physiological

characteristics that allow enhanced performance on tomato crops. This strain is being reared and sold by insectary companies in British Columbia.

Blackheaded fireworm mating-disruption system field tested A mating-disruption system for blackheaded fireworm (BHF) has been successfully field tested on cranberry farms in British Columbia, Washington, and Wisconsin. When applied by air or chemigation to cranberry beds, the microencapsulated synthetic pheromone camouflages the natural pheromone released by blackheaded fireworm females. The synthetic pheromone makes it difficult for male fireworm moths to find females. The mating-disruption system will reduce, and in some cases eliminate, the need for chemical pesticides for control of this insect. Registration of the microencapsulated product will shortly be under way in Canada and the United States.

Obliquebanded leafroller program developed A program for monitoring and controlling the obliquebanded leafroller (OBLR) on raspberries has been developed. The program involves

- estimation, in spring, of the proportion of plants infested with OBLR
- treatment with a chemical pesticide if more than 10% of plants are infested
- charting OBLR moth flight by weekly monitoring of pheromone traps in May through July
- using the dates of peak flight to estimate when the next generation of larvae will occur
- treatment of the summer generation of larvae with the bacterial insecticide *Bacillus thuringiensis*.

Use of this program significantly reduces the number of leafrollers that contaminate harvested fruit and reduces the amount of chemical pesticides applied.

Inexpensive biological control identified for raspberries The two-spotted spider mite is an important pest of raspberry crops. Growers control it only through avoiding sprays that kill its native predators. Occasionally, however, growers must spray for pests such as loopers, which contaminate mechanically harvested fruit. As an alternative control, a looper predator was found, which establishes in raspberry fields at low prey density and contributes to biological control. This predator, *Phytoseiulus persimilis*, is mass reared for use in greenhouses and is therefore available to raspberry growers at relatively low cost.

Monitoring methods assessed for root maggot Several species of root maggots infest canola and cause significant yield reductions each year. The first step in developing comprehensive integrated pest management (IPM) programs for this pest complex is to determine the relative spatial and temporal abundance of the individual species involved. To this end, a number of trapping methods were assessed, and protocols were developed for conducting initial surveys or for routinely monitoring these pests in future IPM programs.

Trapping device for Colorado potato beetle Colorado potato beetles are the most important insect pest of potatoes in North America and Europe. These beetles invade potato fields primarily by walking in from adjacent overwintering sites in the spring. A molded plastic trapping device has been developed and successfully tested that intercepts and kills these beetles en route to potato fields. The device is currently at the patent-pending stage.

Trap crop method developed for wireworm control Several vegetable, berry, and ornamental crops are under increasing attack in the Fraser Valley of British Columbia by two imported European wireworms:

- *Agriotes obscurus*
- *A. lineatus*.

There are currently no methods of effective control for these pests in many of the affected crops. A method of trapping and killing the majority of wireworms in a field using trap crops of densely planted wheat was developed. This new technique will be implemented by strawberry and potato growers in 1997.

Apple orchard irrigation systems compared The performance during the first five growing seasons of high-density, fertigated apple orchards was compared under two irrigation systems:

- drip
- 'microjet' low pressure.

Tree growth was better in the first 2 years under drip irrigation; during the 3rd year, potassium deficiency developed, resulting in less vigorous growth in the drip-irrigated trees. By the 5th year 'microjet'-irrigated trees were performing better over all.

Apple pigmentation augmented Urea sprays augment green pigmentation in Granny Smith and Newtown apples at harvest and retard commercially undesirable yellowing of fruits of Granny Smith, Mutsu, Newtown, and Shamrock during air storage at 0°C. Four weekly sprays of 0.5 and 1% urea prior to harvest are effective and do not adversely affect fruit quality or cause disorders.

Neem oil identified as biological control Neem oil is a natural product that comes from the Indian neem tree. It was shown to deter feeding and interfere with normal development of the pear sawfly, *Caliroa cerasi* L., a pest of pears and cherries. Neem may be useful as a control material for this pest in organic fruit production.

Flaxseed gum substituted as flour improver Flaxseed gum was added as a flour improver at 0.1 or 0.5% level to plain muffins. Physicochemical techniques and a trained sensory panel were used to evaluate and compare the characteristics of muffins containing

- flaxseed gum
- xanthan gum
- guar gum.

The results indicate that muffins containing flaxseed gums have physical and sensory characteristics comparable to muffins made with blends containing xanthan or guar gum.

Four new anthocyanins isolated from bulbs of red onions The color of red onions is due mainly to the presence of anthocyanins, found in the epidermal cells of the scale leaves of the bulb. The four major anthocyanins have been isolated, characterized, and reported in the literature. Recently, researchers isolated and characterized four new minor anthocyanin pigments from three red onion cultivars. The structures have been determined by chemical and spectroscopic methods. This finding is the first report of the occurrence of simple and acylated peonidin glucosides in onions.

Anthocyanin pigments extracted from purple sunflower hulls Interest is increasing in identifying sources of natural food ingredients, especially colorants. Among sources of natural colorants, purple-hulled sunflower has received considerable attention. In this study, the anthocyanin pigments in hulls of purple sunflower seeds were extracted using three solvent systems. Possible factors affecting yield of extracted anthocyanins were investigated, namely

- solvent
- extraction time
- size of ground hulls
- pH of extracting solvent
- hulls-to-solvent ratio
- concentration of SO₂ in water.

All were significant.

Bag types evaluated for modified-atmosphere-packaging (MAP) Nine polyethylene MAP bag types from three suppliers were evaluated for three gas transmission rates at four temperatures. Comparison to suppliers' specifications for oxygen transmission rate showed considerable variation. Average difference was

- 16.7% for supplier A
- 25.1% for supplier B
- 74.4% for supplier C.

Apple juice clarified Ultrafiltration through membranes having a molecular weight cut off of 10 000 kDa effectively removed haze-forming precursors in apple juice produced commercially and in the laboratory. Ultrafiltration is a commonly used commercial technique for juice clarification. Attention paid to the details of the technique may pay dividends related to haze avoidance.

Oxidase enzymes identified in haze formation in fruit juices Particle-size development in fruit juice and model systems derived from fruit juice was assessed by light-scattering techniques. Results strongly suggest an enzymatic origin for development of fruit juice haze. Common pasteurization regimens generally destroy the enzyme polyphenol oxidase, but peroxidase can catalyze similar oxidation reactions, is heat resistant and can regenerate after inactivation.

Yield and quality of juice enhanced Basic research was done to describe practical operational and enzyme requirements for centrifugal extraction of fruit juice. This work has contributed significantly to enhancement of yields and quality of juice from an apple juice plant in Nova Scotia. The research contributed to its ongoing competitive position.

Sensory methodology applied and developed Work was done in several areas.

- The sensory characteristics of new cherry and grape cultivars were profiled to establish the necessary information for naming and release.
- Multiple regression models were developed for prediction of visual and flavor–texture liking of sweet cherries.
- A photographic scale was developed for the evaluation of degree of striping in 'striped' apple cultivars.
- The quality characteristics of British Columbian Pinot noir and Chardonnay wines were documented.
- The sensory properties of microperforated-wrapped and modified-atmosphere-packaged broccoli were evaluated.

Cellulose secretion discovered in recently isolated bacterial strain Although rare, cellulose synthesis is known to occur in a few bacteria. *Acetobacter xylinum*, a strictly aerobic bacterium used in the manufacture of vinegar, can be used to produce cellulose by fermentation. The strict oxygen requirements and relatively slow growth rate of the species have, however, hampered commercial exploitation. A facultatively anaerobic bacterium that produces cellulose rapidly was recently isolated. This strain could be used for large-scale, industrial production of microbial cellulose, a polymer with unique and useful physical properties.

Disinfectant treatment for vegetable sprouts Vegetable sprouts, including alfalfa, radish, and mung bean sprouts, have been implicated in cases of food poisoning. An effective, safe disinfectant treatment has been developed, which destroys three disease-causing organisms on seeds:

- *Salmonella* spp.
- *E. coli* O157:H7
- *Listeria monocytogenes*.

The treatment could also be used to disinfect other commodities such as eggs.

Horseradish oil revealed as powerful antimicrobial Essential oils recovered from horseradish root by steam distillation contain a mixture of isothiocyanates. These compounds have been shown to have a role in the prevention of cancer. Research has revealed that the oil is also a powerful antimicrobial, effective against

- food-borne pathogens

- spoilage bacteria
- molds.

Further research will determine the performance of horseradish oil as a preservative in food systems.

Cold pasteurization of fruit juices studied A 3-year collaborative project was done with industry on cold pasteurization of fruit juices. Factors influencing the physicochemical and sensory properties of clarified apple juices designated golden and light were

- membrane pore size
- processing procedures
- storage conditions.

The commercial potential of specific juices has been identified and technology transfer initiated.

Cherry cultivars characterized Four promising numbered selections and eight established sweet cherry cultivars were characterized for their acid constituents and sugar and volatile profiles. Multivariate analyses demonstrated clear delineation among cultivars based on analytical data and relationships between other compositional factors such as

- weight
- soluble solids
- titratable acidity
- pH
- color.

Carrot-blanching effects studied Water blanching effects on headspace volatiles and sensory attributes of carrots were studied. Most carrot volatiles, in particular terpenoids, decreased by at least 50% within 60 seconds of blanching. Sensory rating decreased with blanching time for

- color
- texture
- raw carrot aroma
- sweetness
- flavor
- overall impression.

Cooked carrot aroma increased.

Fumigation prevents disease growth Results included the following.

- Fumigation of Summerland Selection 651 table grapes with acetic acid was as effective as sulfur dioxide in preventing gray mold decay.
- Fumigation of harvested stone fruit with acetic acid controlled brown rot and *Rhizopus* rot but caused brown streaks to form on peaches.
- Fumigation of grain and oilseed with high moisture content prevented storage mold from growing on small samples of seed stored for up to 8 weeks.

Antibiotic from apples identified An antibiotic with antifungal properties produced by *Bacillus subtilis* was isolated from stored apples. It was identified as an acidic peptide with a molecular weight of 1.5 kDa, forming micelles in excess of 20 kDa. It was categorized as a biosurfactant antibiotic.

Powdery mildew identified on ginseng Powdery mildew was identified for the first time on ginseng in North America.

Endogenous antioxidant capacity increased in broccoli Both low temperature storage and hot water dips increase endogenous antioxidant capacity in broccoli. This may be the physiological basis for reduction of yellowing in broccoli that has been stored at low temperatures or treated with hot water dips.

Apple rootstock trials completed Several rootstock trials conducted over the past 12 years have been completed and the results published. Three dwarfing rootstocks have been identified:

- P.2
- Budagovsky 9
- Ottawa 3.

Yield and precocity of bearing of these rootstocks are about as good as M.9EMLA. Budagovsky 9 and Ottawa 3 are now being planted in the colder regions of the Okanagan Valley. P.1 is a cold-hardy rootstock in the semi-dwarf class. It is similar to M.26 in size and is as productive and precocious, so has the potential to replace it. Budagovsky 118 and M.4 are more cold resistant than M.7, a commonly used semi-vigorous rootstock, but they produce larger trees with lower precocity.

Apple tree shape affects orchard design Tree shape can affect orchard productivity and fruit quality. A study of three diverse tree shapes was done on the dwarfing rootstock M.9 at five tree densities and constant rectangularity:

- tall
- slender spindle
- Y trellis.

No difference in yield up to the 4th year was found among treatments. But at high densities the fruit on the Y trellis was more poorly colored than that on other tree shapes. This information will be used to improve orchard design of high-density orchards grown on M.9.

Apple catalog distributed A catalog of 16 apple selections at the test market stage has been distributed to commercial testers and to research cooperators from the apple-breeding program. The catalog contains all the information collected on the selections, including the 1996 taste panel results and storage test.

Movement of tomato mosaic virus studied Researchers compared three characteristics of tomato mosaic virus strains L and LS₁ at 22°C and 32°C in the C₄ plant *Gomphrena globosa* (globe amaranth), namely

- symptom development
- virus multiplication
- distribution.

Results of this study demonstrated that the movement protein of tobamoviruses may be multifunctional, involved in both 'long-distance' and 'cell-to-cell' movement. This work may facilitate the design of nonfunctional, truncated movement proteins for transformation of crop plants, with the potential to confer plant resistance.

Flavonoids as antiviral compounds Flavonoids and related compounds, when added to a mixed inoculum containing tomato ringspot virus (TomRSV), inhibited infectivity of the virus in *Chenopodium quinoa*. A total of 48 compounds were screened and 15 showed strong antiviral activity at low concentrations. Flavonoids and related compounds have the potential to eliminate viruses from infected tissue cultures using chemotherapy. Chemotherapy in tissue culture offers an alternative to thermotherapy to eliminate viruses from infected clones. The resultant healthy plant material can be used in virus-free production schemes and plant breeding. It will meet international quarantine regulations for exchange of plant material.

Proteolytic cleavage in tomato ringspot virus studied Tomato ringspot virus is a nepovirus of economic importance on fruit trees and small fruits in North America. The viral proteins are produced by cleavage of a precursor polyprotein through the action of a virus protease. This proteolytic cleavage is an essential step in the life cycle of the virus. Inhibition of proteolytic cleavage in tomato ringspot virus or other related viruses would prevent the virus from accumulating.

Results of the study:

- The protease was cloned and characterized.
- It was found to recognize a cleavage site between the viral-movement protein and coat protein, thereby allowing the release of those proteins.
- This cleavage was analyzed in vitro, in plants, and in protoplasts infected with the virus.
- The nature of the cleavage site was determined.
- The nature of the cleavage site was found to differ from other characterized nepoviruses.

These results have important implications on the mechanism of proteolytic cleavage. This knowledge will be used in future work in the design of protease inhibitors that could be expressed in transgenic plants to provide increased resistance to virus infection.

Nitrate assumptions proven incorrect Contrary to what has been commonly assumed, nitrate is adsorbed by south coast British Columbian soils. Additional research will determine its quantitative measurement. The occurrence of the process has important implications to interpretations of soil nitrogen research data, including the development and validation of simulation models.

Heavy metal levels studied Cadmium, lead, copper, zinc, and molybdenum concentrations in vegetables grown in three commercially important regions of the Lower Fraser Valley are generally acceptable for human health considerations. However, areas influenced by marine-type salts tend to have increased concentrations of plant metals. This occurrence needs further investigation for health reasons and for the development of guidelines for basalt applications to agricultural land.

Soil test analyses interpreted Soil test analyses for nitrogen, phosphorus, potassium, and magnesium were interpreted for hazelnuts.

Soil tests rejected for fertilizer recommendations Many laboratories use soil tests for sulfur that are based on a method which only extracts the sulfur in soil solution. These tests are not acceptable for making fertilizer recommendations for crops grown in soils on the south coast of British Columbia. These soils adsorb sulfate so the result of current tests is always low. A new test is needed that will be suitable for soils from this area.

Organic-based fertilizers developed Pelleted, organic-based fertilizers were produced by blending composted poultry manure and other organic ingredients with inorganic fertilizers. Two of the fertilizers were tested for broccoli production. Yields were greater with the organic-based fertilizer than with similar quantities of inorganic fertilizer blends specifically designed for cole crops.

Poultry ammonia emissions decreased Control of ammonia emissions from poultry production is important for bird health and environmental air quality. Dietary changes can help decrease ammonia emissions. Broilers fed diets lower in total protein but balanced for amino acid requirements scored higher in bird health than birds fed standard diets.

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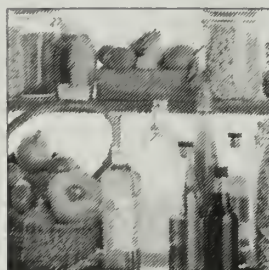
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